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THE EFFECTS OF THE UPPER OTTAWA STREET LANDFILL ON REDHILL CREEK

November 1978

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R43
1978
MOE

Ontario

Ministry
of the
Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

K.H. Sharpe,
Deputy Minister

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THE EFFECTS OF THE UPPER OTTAWA STREET LANDFILL ON REDHILL CREEK

WATER RESOURCES ASSESSMENT
TECHNICAL SUPPORT SECTION

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INTRODUCTION:

The Ottawa Street sanitary landfill is located immediately adjacent to Redhill Creek. The creek has a total drainage area of 21.2 square miles, and the entire watershed is being rapidly urbanized. Numerous storm and four combined sewer storm by-passes discharge to the creek. Base flow in the vicinity of the landfill during the study period was approximately 1 to 2 cfs. The landfill has been active for 20 years and has accepted domestic and industrial waste throughout its lifespan. The site is reapidly approaching capacity and is to be closed by 1980. Leachate springs and runoff from the landfill have been reaching Redhill Creek for many years (H.R.C.A., 1975). A visual inspection shows that in several places the toe of the landfill is encroaching on the watercourse. Further interest in this landfill was stimulated by the disposal of liquid industrial wastes and the operation of a heavy metal fixation plant at this site. Early this spring, the Municipal and Private Section of the West Central Region requested that a study be carried out to quantify the effects of the landfill on Redhill Creek.

SURVEY METHODS:

Sampling stations were selected as shown in Figure 1 along Redhill Creek. Leachate springs and surface runoff from the sanitary landfill were sampled to determine the nature of the waste loadings. Upstream controls RH14, RH15 and RH12 were selected to determine background levels in Redhill Creek. Downstream RH13 and RH11 were used to show overall effects on the creek. The station at Mount Albion Falls (RH11) was selected to allow for contribution to the creek from any contaminated ground water in the area.

Samples were obtained by the M.O.E. in the first half of each month (March, April, May, June) during the period of higher streamflows in Redhill Creek. The Regional Municipality of Hamilton-Wentworth carried out a series of sampling

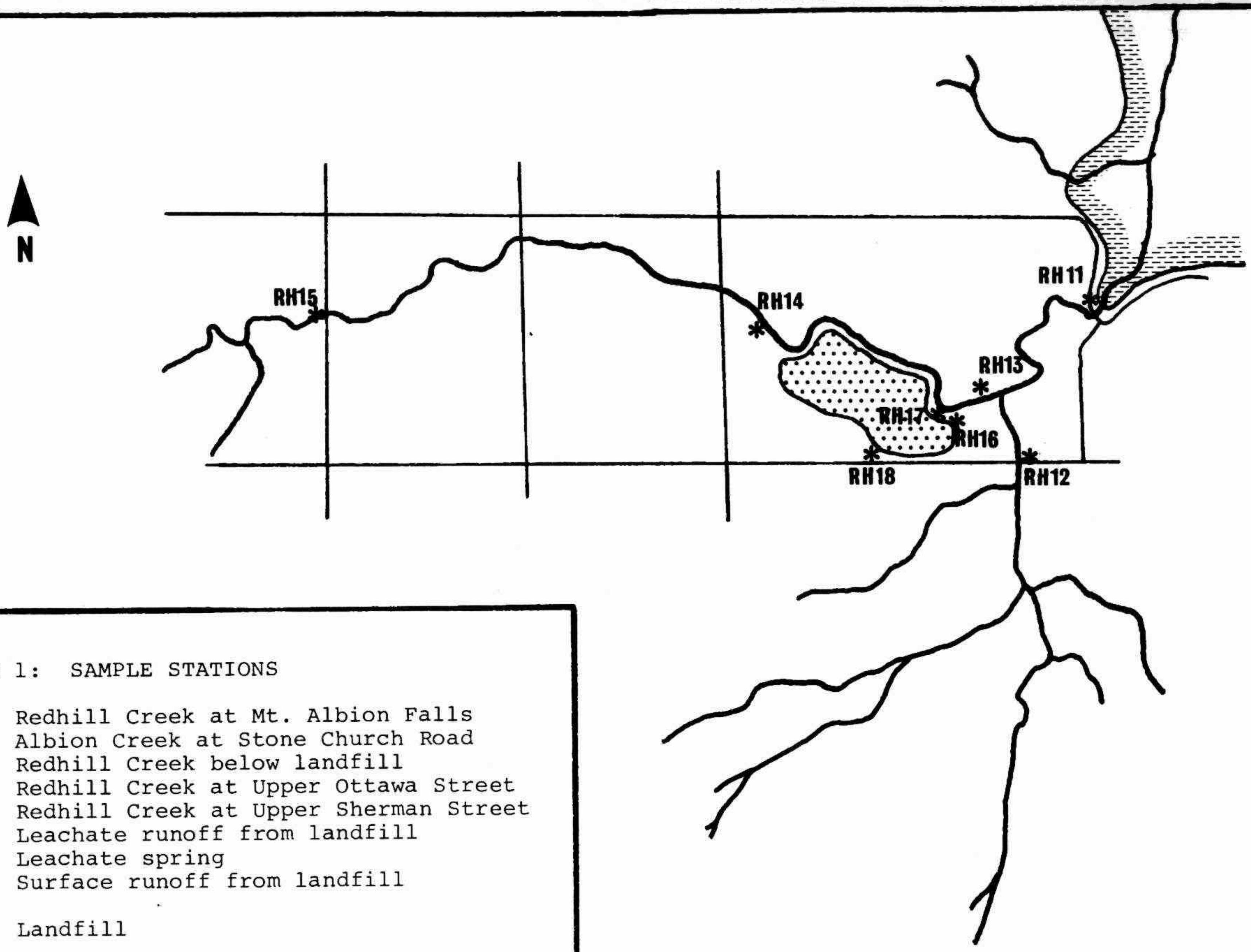

FIGURE 1: SAMPLE STATIONS

RH11: Redhill Creek at Mt. Albion Falls
RH12: Albion Creek at Stone Church Road
RH13: Redhill Creek below landfill
RH14: Redhill Creek at Upper Ottawa Street
RH15: Redhill Creek at Upper Sherman Street
RH16: Leachate runoff from landfill
RH17: Leachate spring
RH18: Surface runoff from landfill

⁙ Landfill

▤ Edge of Escarpment

during the second half of each month. During low summer flows (1 to 2 cfs at the landfill) the sampling frequencies were increased to twice a month (July, August) by the M.O.E.

LEACHATE:

Theoretical calculations on the volume of leachate generation based on average yearly rainfall and average infiltration for landfill sites indicate that an estimated volume of 25 X 10^6 gallons per year could be infiltrating the landfill site (Fenn et al, 1975, Hydrology Consultants Limited, 1976). Estimated flows out of this site (including leachate springs and runoff) total about 10 gallons per minute or approximately 5.25 X 10^6 gallons per year. A possible reason for this difference is that the landfill has not yet reached field capacity. That is, the interstitial voids in the waste are still filling. When these are full and the site has reached field capacity, the actual volume of leachate leaving the landfill should equal the amount of infiltration. Thus, the potential exists for increased leachate generation in the future.

Steps to seal the landfill to minimize infiltration should have a high priority. This would include stabilizing the sides, covering with a layer of clay, and the establishment of vegetation on the surface.

The chemical nature of the leachate is shown in Table 1. Heavy metals were all present at very low levels and did not seem to be a cause for concern. Bacterial degradation of organic refuse in the landfill results in the production of weak organic acids through fermentation, and where oxygen is available, an increase in the partial pressure of CO_2 and a resultant decrease in pH (Berner, 1971). This lowering of pH will increase the solubility of the heavy metals. When the leachate leaves the landfill and equilibrates with the

TABLE 1

COMPOSITION OF LEACHATES IN mg/l

STATION		TOTAL SOLIDS	COD	CHLORIDES	NH_3	TKN	TOTAL P
RH16	$\bar{x}$	10,950	1,600	2,900	260	320	2.7
	s	3,100	800	870	55	61	.8
RH17	$\bar{x}$	8,600	2,700	1,800	450	660	10.0
	s	1,200	1,400	330	100	160	2.3
RH18	$\bar{x}$	8,000	1,200	2,800	120	150	2.1
	s	2,700	380	2,100	32	27	.70

TABLE 2

HEAVY METALS IN LEACHATES IN mg/l

STATION		CADMIUM	COPPER	LEAD	NICKEL	ZINC
RH16	$\bar{x}$	.008	.048	<.06	.150	.295
	s	.006	.021	.046	.062	.073
RH17	$\bar{x}$	.008	.095	<.06	.06	.330
	s	.004	.064	0	0	.042
RH18	$\bar{x}$	.008	.072	.554	.245	.694
	s	.007	.044	1.14	.154	.646

Note: $\bar{x}$ = Arithmetic Mean

s = Standard Deviation

atmosphere, "degasing" of CO_2 and/or oxidation of the organic acids results in an increase in the pH, thereby decreasing the solubility of the metals. Thus metals in the leachate are precipitated in the outer fringe of the landfill and do not migrate beyond. A shallow well was drilled to a depth of three meters into the interim cover material at station RH17. Samples from this well did not reveal appreciable concentrations of soluble metals at this depth in the landfill.

The leachate contained high levels of chlorides (approximately 2,000 mg/l), COD (approximately 1,500 mg/l), and total solids (approximately 9,000 mg/l). BOD values were lower than expected but this may have been due to the toxicity of the concentrated leachate to the seed organisms. Interference in measurements of BOD in landfill leachate is a common analytical problem (Mooij 1975).

The nutrient levels in the leachate were extremely high, particularily the nitrogens. Total Kjeldahl Nitrogen (TKN) and Free Ammonia concentrations in excess of 200 to 250 ppm were common. Values of nitrate and nitrite were very low reflecting the reduced nature of the waste. Total Phosphorus concentrations were high ranging from 2.5 to 10 ppm. Soluble Phosphorus varied from 1 to 4.5 ppm. All dissolved oxygen measurements made on the leachate revealed 0.0 D.O.

The results of individual samples of the leachate throughout the site were highly variable; however, the samples taken from individual locations in the landfill over the study period revealed consistent chemical characteristics, probably due to the nature of the degrading refuse in the source area.

Chemical concentrations of the Upper Ottawa leachate did not appear significantly different from the range of values for leachate from other sanitary landfills (Hughes et al, 1971; Griffins et al, 1976).

EFFECTS ON REDHILL CREEK:

Organic Chemicals

Samples taken at RH11 contained phenol concentrations of 0.1 ug/l. PCBs were present at .03 ug/l in Redhill Creek at Mount Albion Falls (RH11). Samples of the leachate from the site taken in 1977 produced results of .2 to .9 ug/l (Ehlert, 1978). PCB levels measured in the creek were identical above and below the landfill (.03 ug/l).

Heavy Metals

Figures 2 through 9 show the level of various metals in Redhill Creek as it flows past the landfill site. It can be clearly seen that values of As, Cd, Cu, Pb, Fe, Mn, and Ni did not significantly increase downstream. Zinc increased two and on-half times from .025 mg/l to .060 mg/l at Mount Albion Falls.

To determine the nature of the variation of individual metal concentrations, the sample results for Fe and Zn were correlated with suspended solids and turbidity for all stations. While turbidity did not display any relationship with the metal concentrations, suspended solids showed a positive correlation with both Fe and Zn at the 99% confidence level. Most of the metals were therefore being transported sorbed on the surface of the particulate fraction and are not in the dissolved phase. These results are shown in Figures 10 and 11.

Chemical Parameters

Figures 12 through 26 show variations in conventional chemical parameters in Redhill Creek. Concentrations of most of the parameters (conductivity, total solids and chlorides) increased slightly immediately below the landfill (RH13) but fell to background levels at Mount Albion Falls (RH11).

More serious are the effects of the various products of organic degradation on the stream. Mean BOD_5 levels increased from 1.2 mg/l to 3.5 mg/l downstream of the landfill. All of the nitrogens increased dramatically, primarily due to the addition of ammonia from the landfill, resulting in the immediate oxidation of a small fraction of this, giving large apparent increases in the concentrations of NO_2 and NO_3. Phosphorus does not appear to be a problem attributable to leachates from the landfill site.

Bacteria

Figures 27 through 30 present bacteria levels in Redhill Creek above the escarpment. Each graph shows clearly that the Upper Ottawa Landfill was not causing bacterial problems in the creek. It is readily apparent that bacterial pollution was entering the creek between Upper Gage and Upper Ottawa Streets above the landfill site. The contamination was probably coming from sanitary leakage to storm sewers in the new residential development in this area. The faecal coliform to faecal streptoccus ratio indicates on certain days the bacteria were of recent human origin.

DISCUSSION:

The data collected by the M.O.E. and the Regional Municipality of Hamilton-Wentworth are in reasonable agreement and do not contradict each other. The degradation of Redhill Creek by the Upper Ottawa landfill site is limited mainly to those parameters released by the organic decomposition of domestic waste. Specifically BOD, TDS and NH_3 all increased markedly due to the landfill. Metals, however, do not appear to be a problem, and the most severe bacterial contamination is a result of other sources. The most significant factor in this is the low volume (compared to streamflow) of highly concentrated leachate reaching Redhill Creek and the resultant dilution of the wastes. It was anticipated that greater effects on water quality would be observed during periods of low streamflow but this has not been the case. A study of chlorides, turbidity, total solids and free ammonia at stations RH11 and RH13 showed no discernible seasonal trends. This is probably due to the relationship of the streamflow and leachate generation to rainfall, and the seasonal effects of evapotranspiration on infiltration. The infiltration fraction of the precipitation is the principal contributor to leachate generation from the sanitary landfill, excluding liquid wastes dumped at the site. During 1978, approximately 3.3×10^6 gallons of liquid industrial wastes will be landfilled. This represents approximately 13% of the total infiltration. During late spring, summer and early fall, evaporation rates are adequate to prevent or greatly reduce percolation or infiltration of rainfall into the refuse (Rovers and Farquhar; Fenn et al, 1975). This results in lower volumes of leachate generation. Maximum infiltration occurs during spring thaw (Rovers and Farquhar) concomitant with peak streamflow.

CONCLUSION:

1. Heavy metals are not escaping from the Upper Ottawa Landfill site in appreciable quantities.
2. The major source of bacterial contamination of Redhill Creek above the escarpment is from the residential development upstream of the landfill.
3. PCBs and phenols are not a problem.
4. Pollution of the creek from the landfill is limited to the organic breakdown products of domestic refuse, of which BOD and free ammonia are the most serious.
5. The potential exists for increased leachate generation at the site when the landfill reaches field capacity.

RECOMMENDATIONS:

1. Steps should be taken to reduce the amount of the infiltration of precipitation at the landfill. These include the application of a clay final cover, the establishment of vegetation on the above cover and the stabilization of the sides of the landfill above Redhill Creek.

2. Due to the steep sides of the landfill adjacent to Redhill Creek, the possibility of erosional problems will exist here for years to come. Routine maintenance will be required to keep this under control.

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APPENDIX 1

Graphical Representation of Data

1. The points connected by horizontal lines represent sampling stations in Redhill Creek itself (RH11, RH13, RH14 and RH15).

2. The points not connected by these lines represent tributaries or discharges to the creek.

3. The vertical lines above and below each sample point represent the standard deviation of the mean.

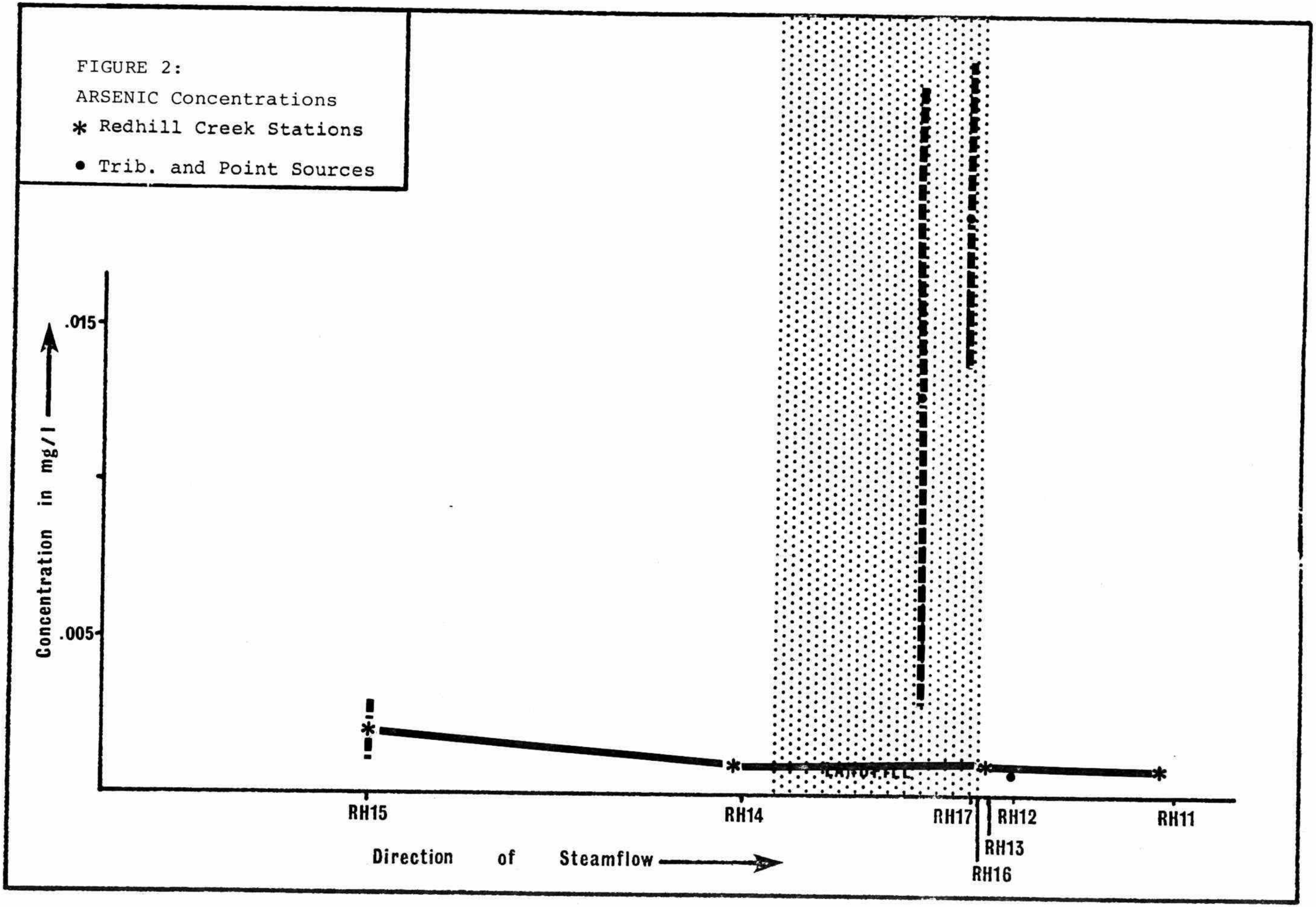
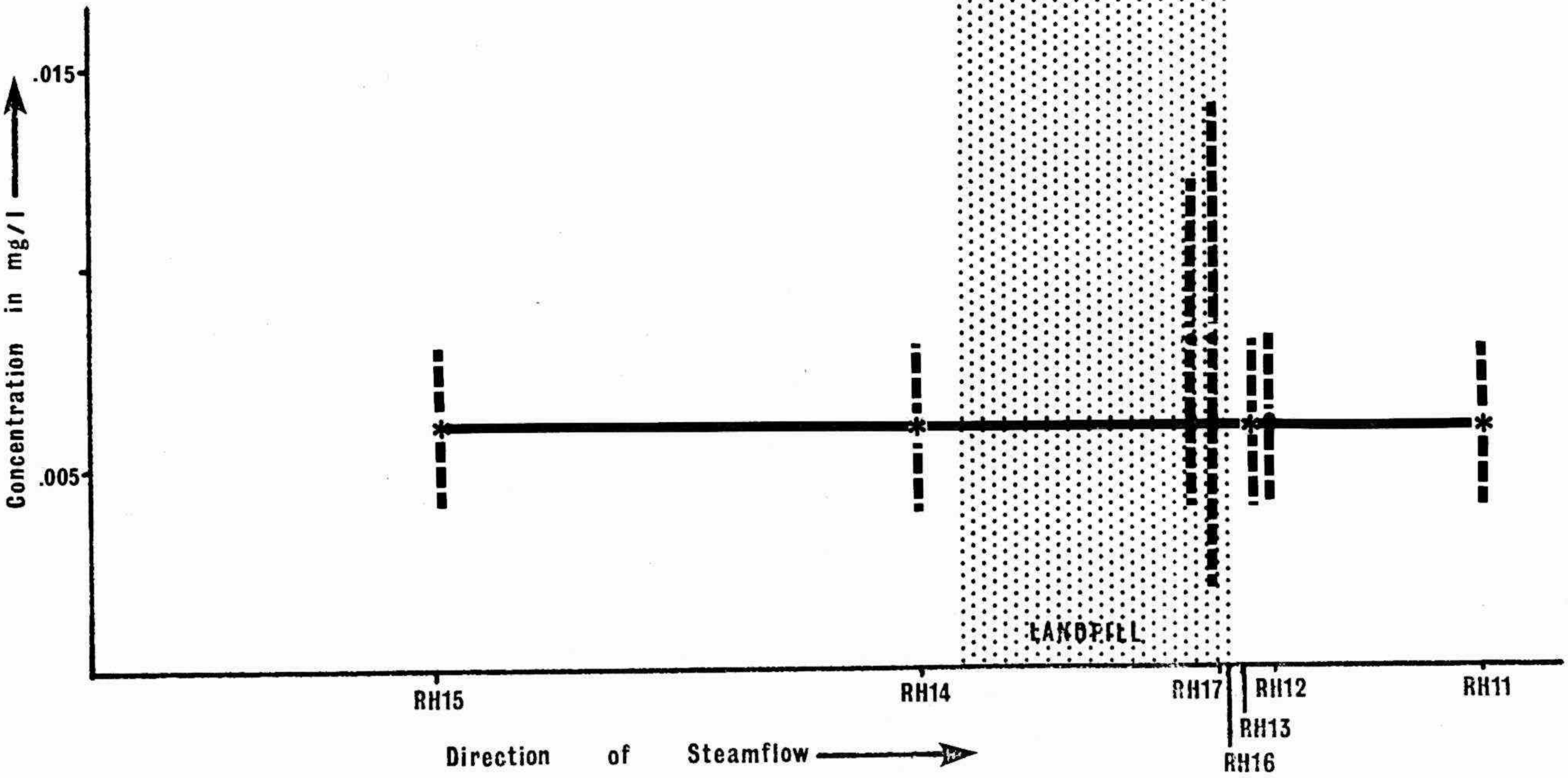


FIGURE 2:
ARSENIC Concentrations

FIGURE 3:
CADMIUM



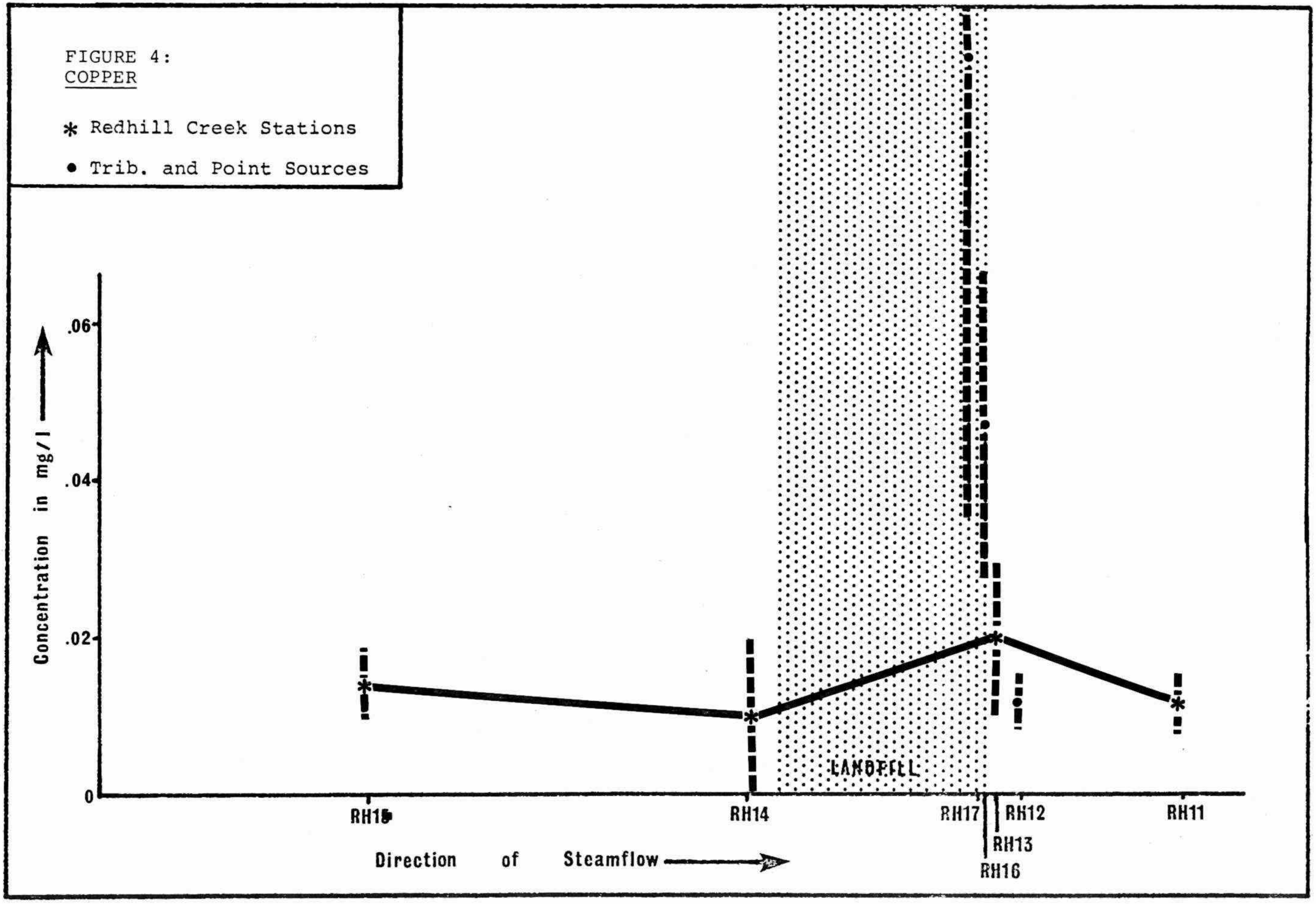


FIGURE 4:
COPPER

FIGURE 5:
LEAD

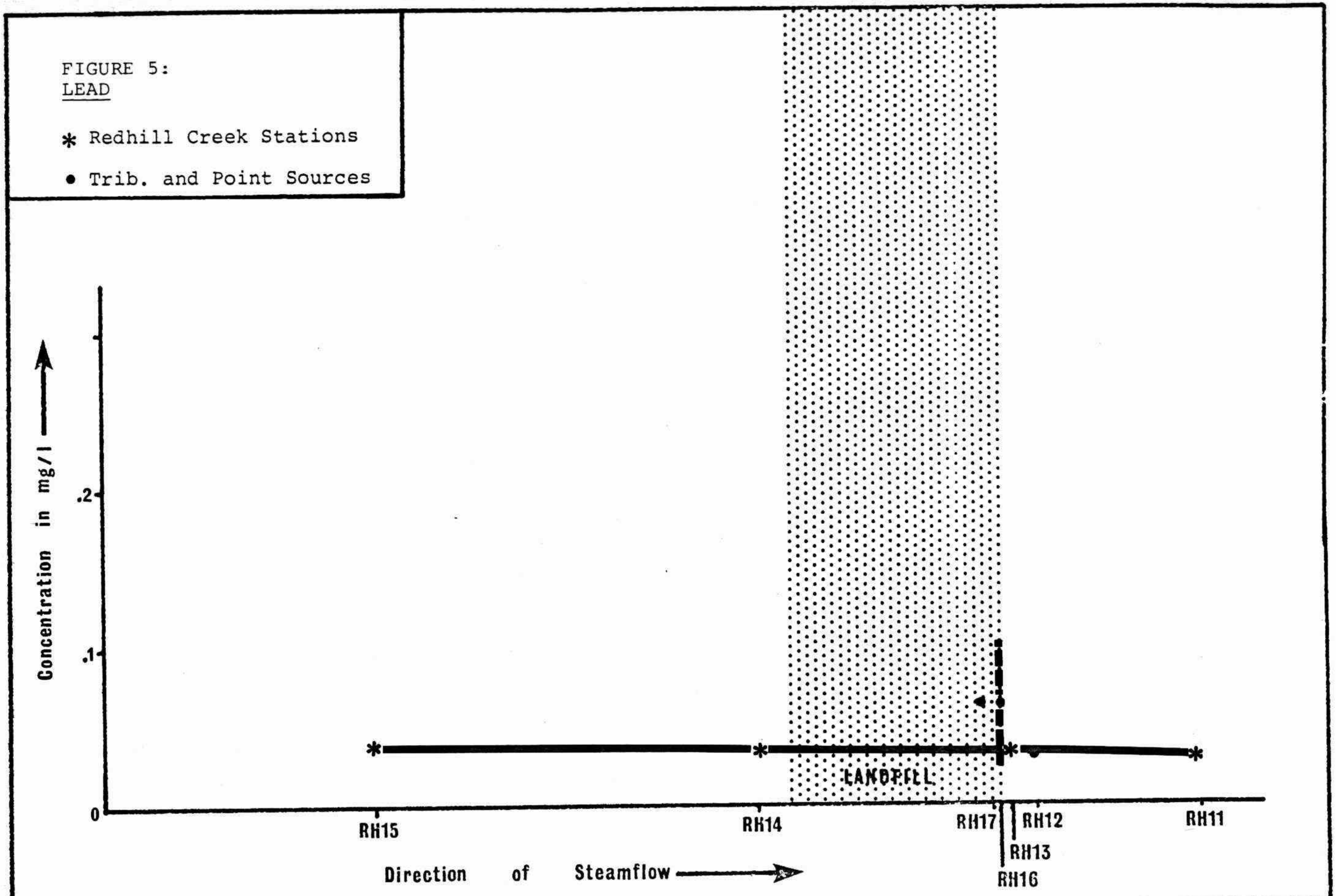
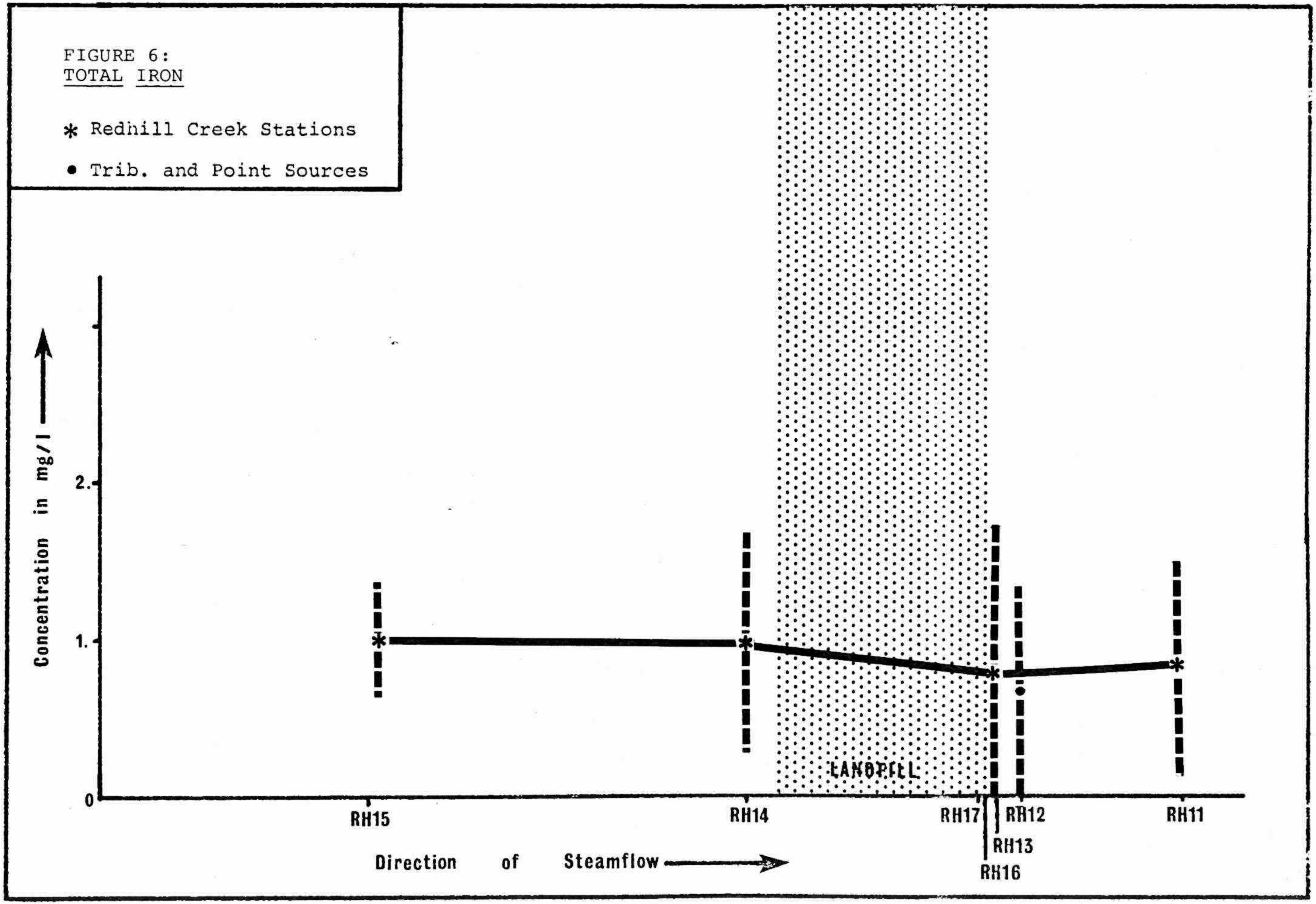


FIGURE 6:
TOTAL IRON



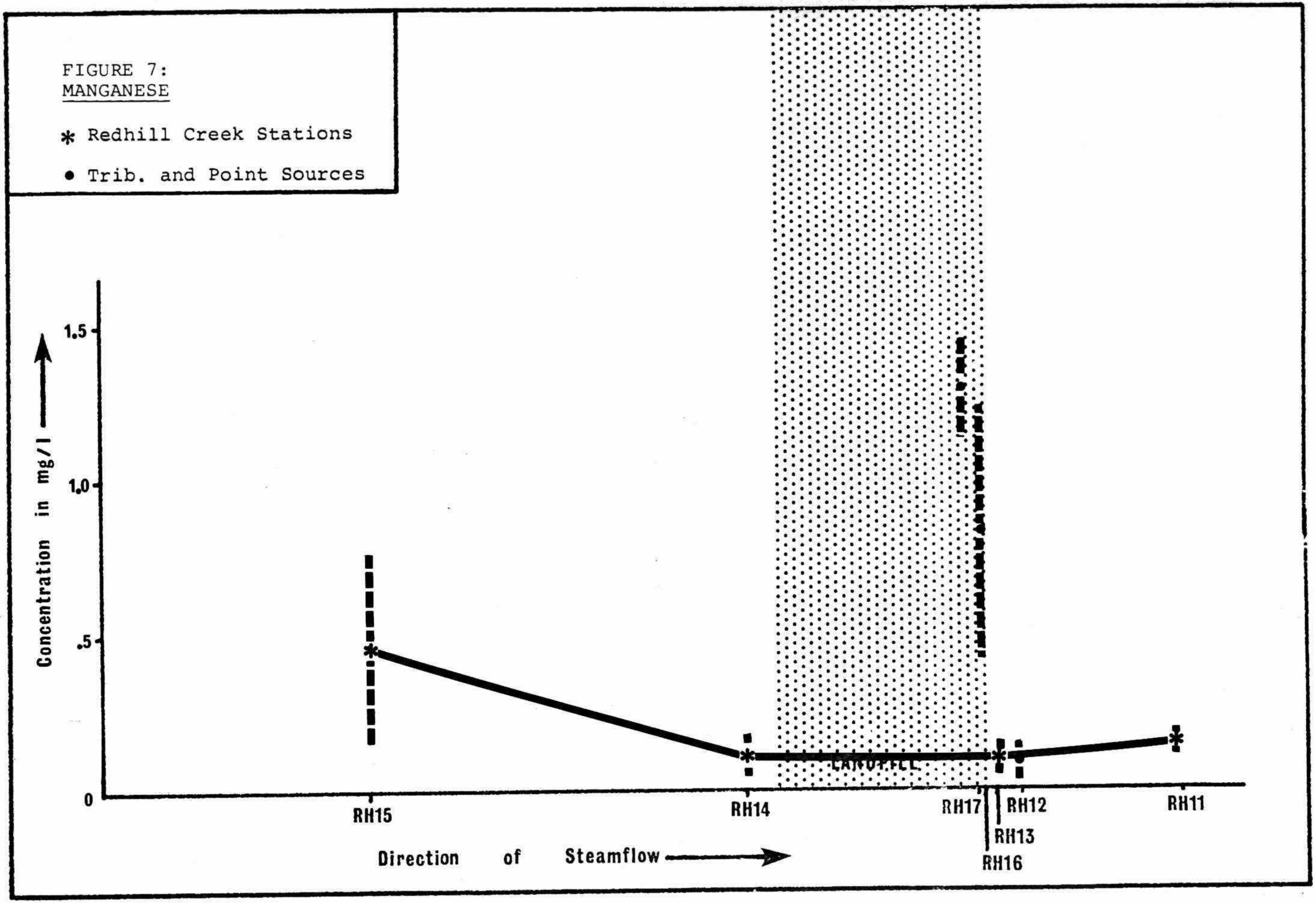


FIGURE 7:
MANGANESE

FIGURE 8:
NICKEL

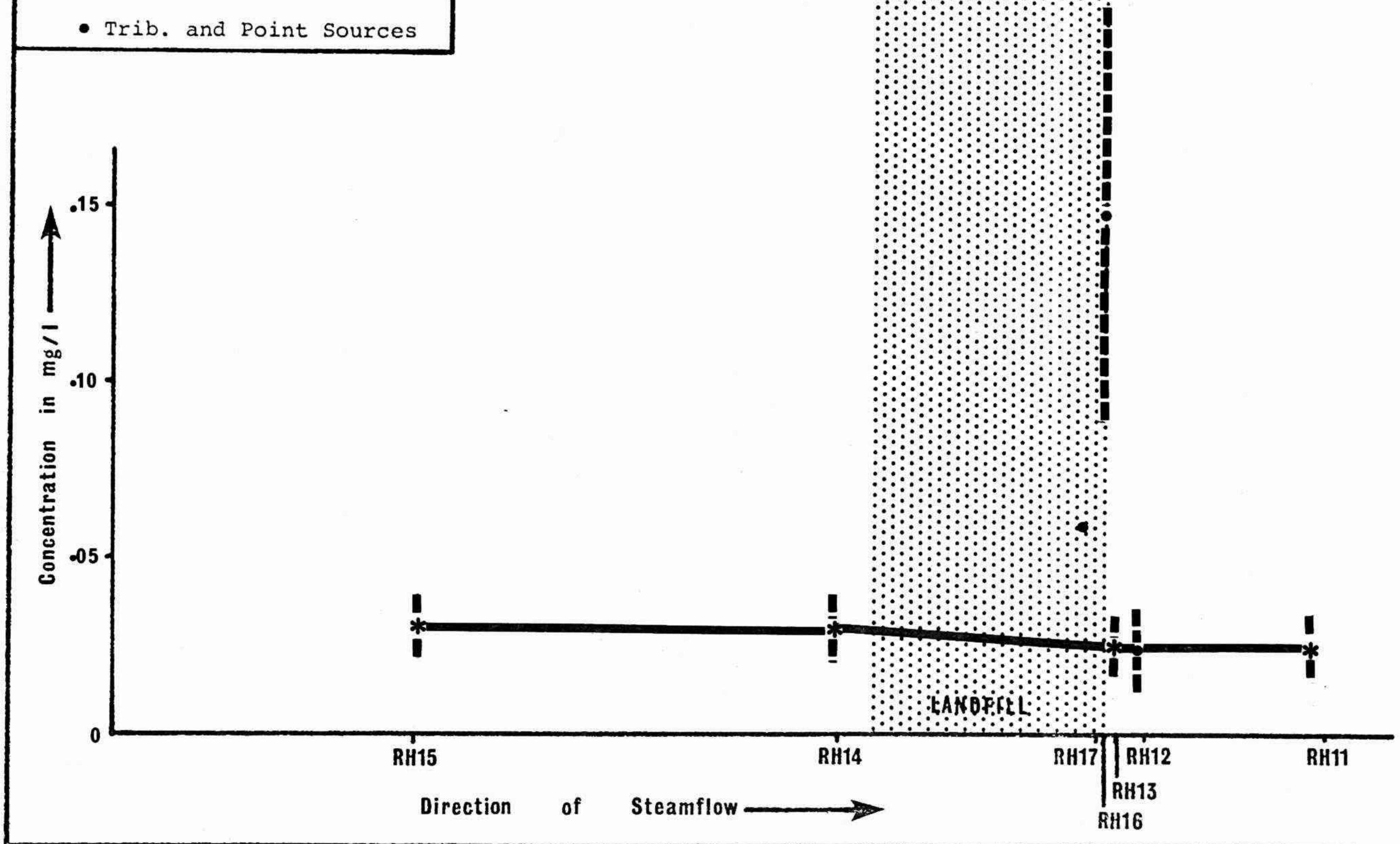
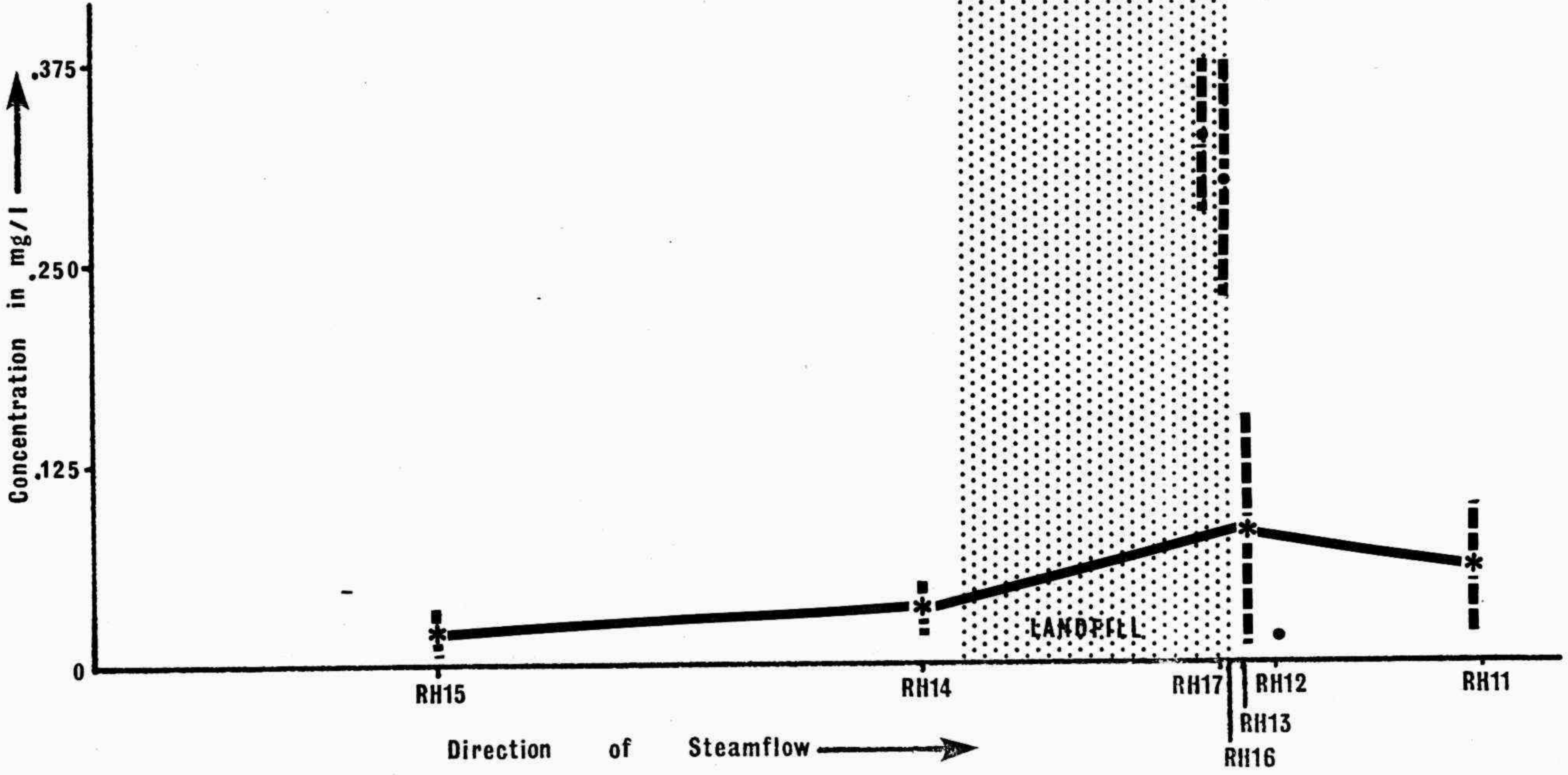


FIGURE 9:
ZINC



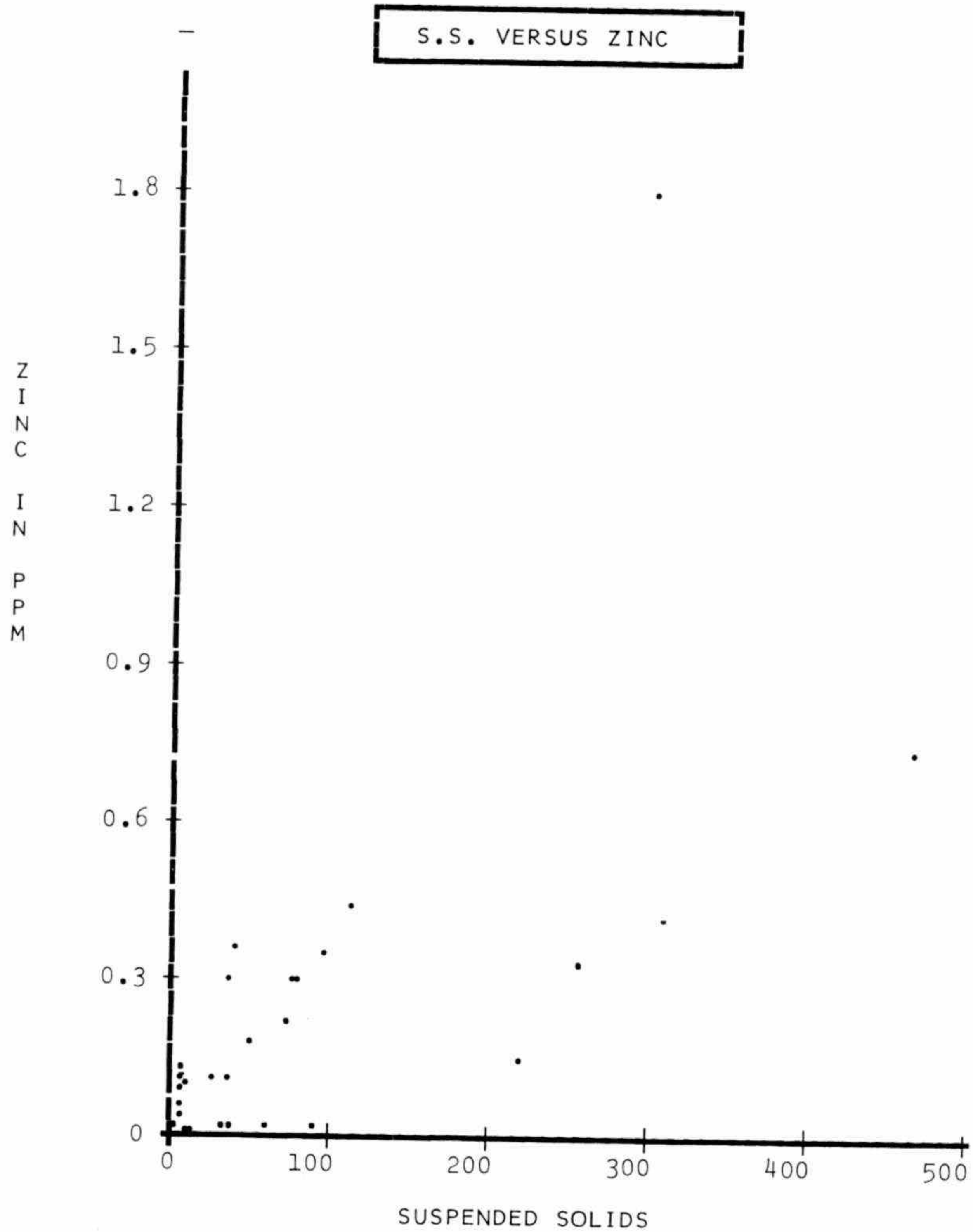


FIGURE 10 : Relationship between Suspended Solids and Zinc.

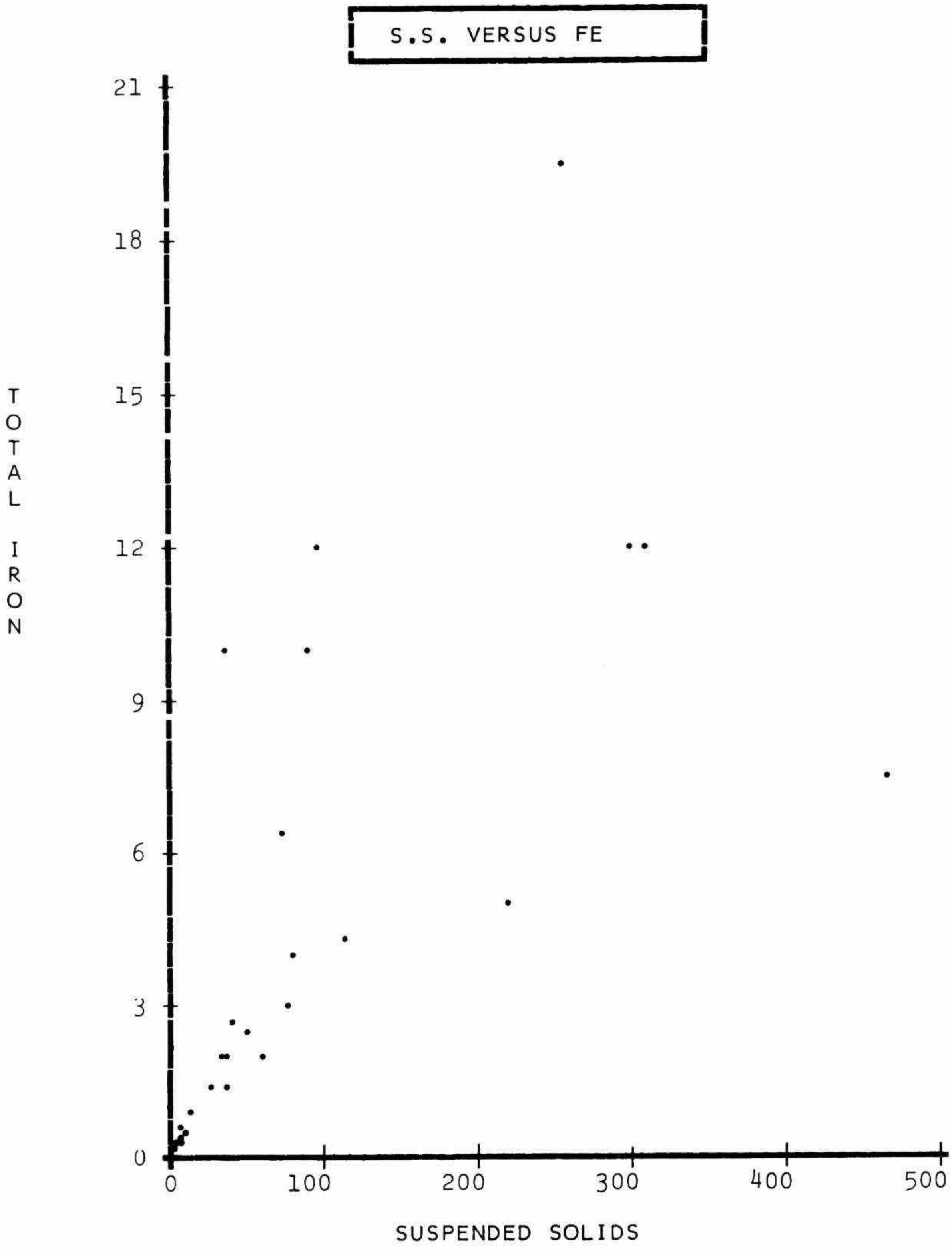
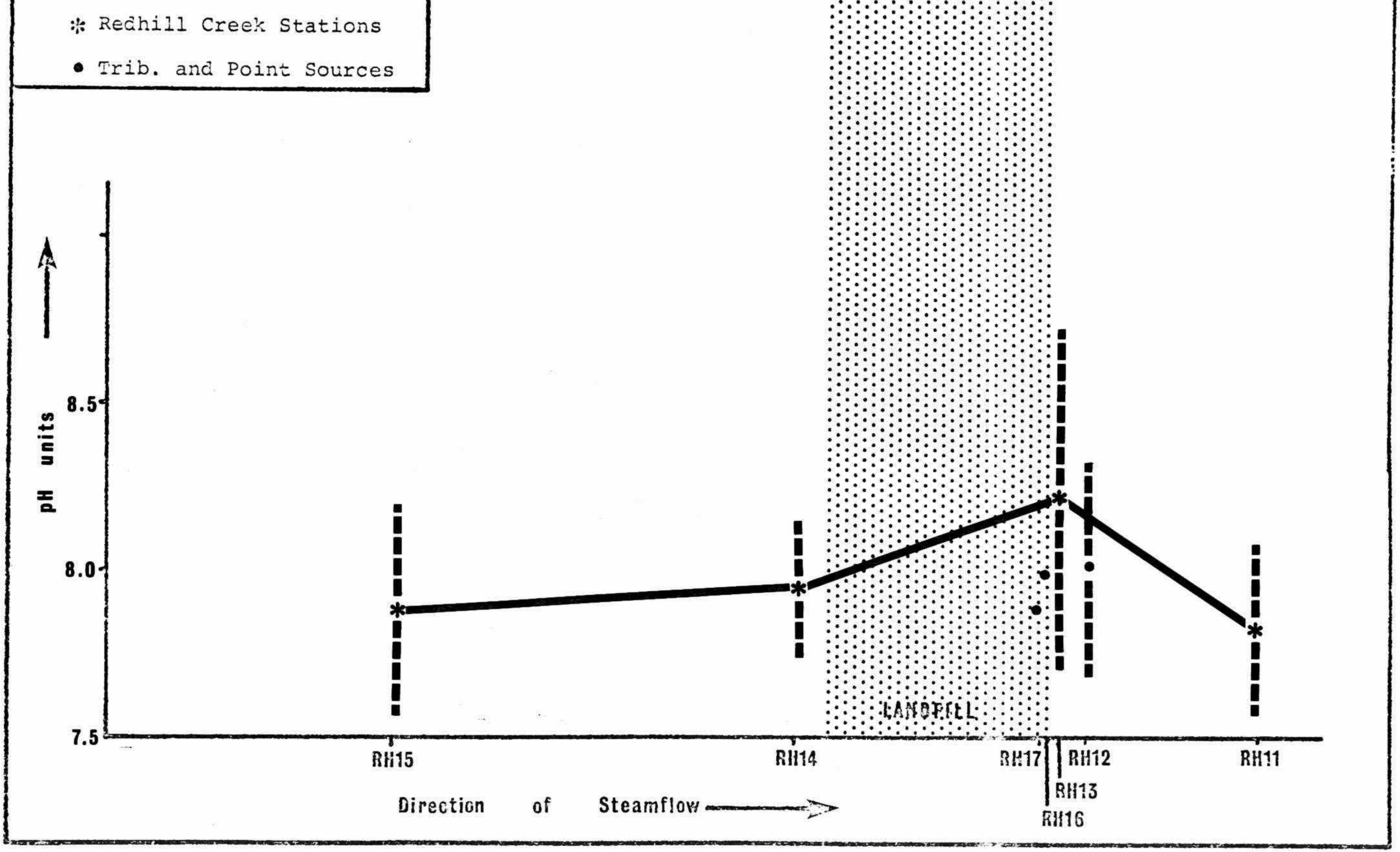


FIGURE 11 Relationship between Suspended Solids and
Total Iron.

FIGURE 12:
pH



* Redhill Creek Stations
● Trib. and Point Sources
pH units
8.5
8.0
7.5
LANDFILL
RH15
RH14
RH17
RH16
RH13
RH12
RH11
Direction of Steamflow

FIGURE 13:
CONDUCTIVITY

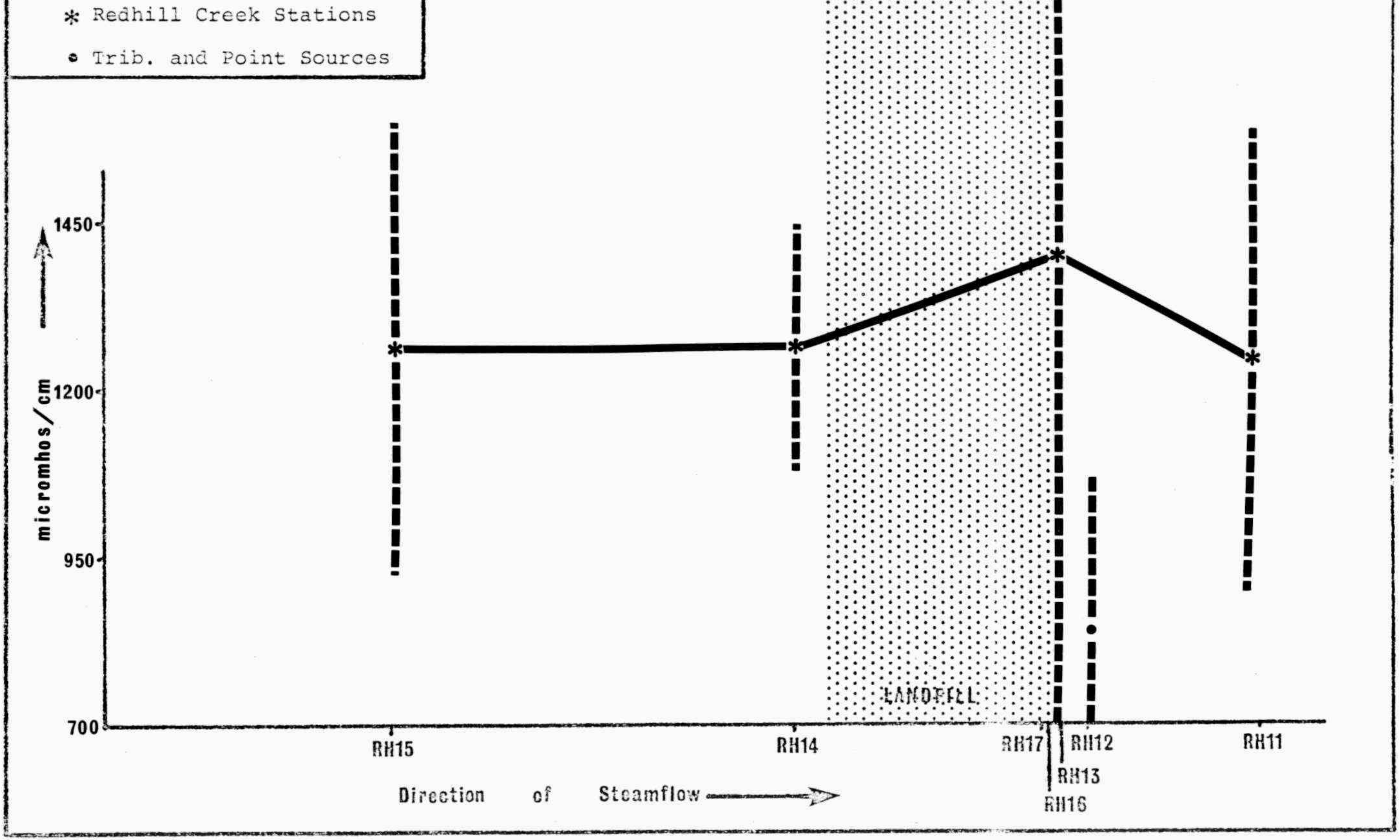
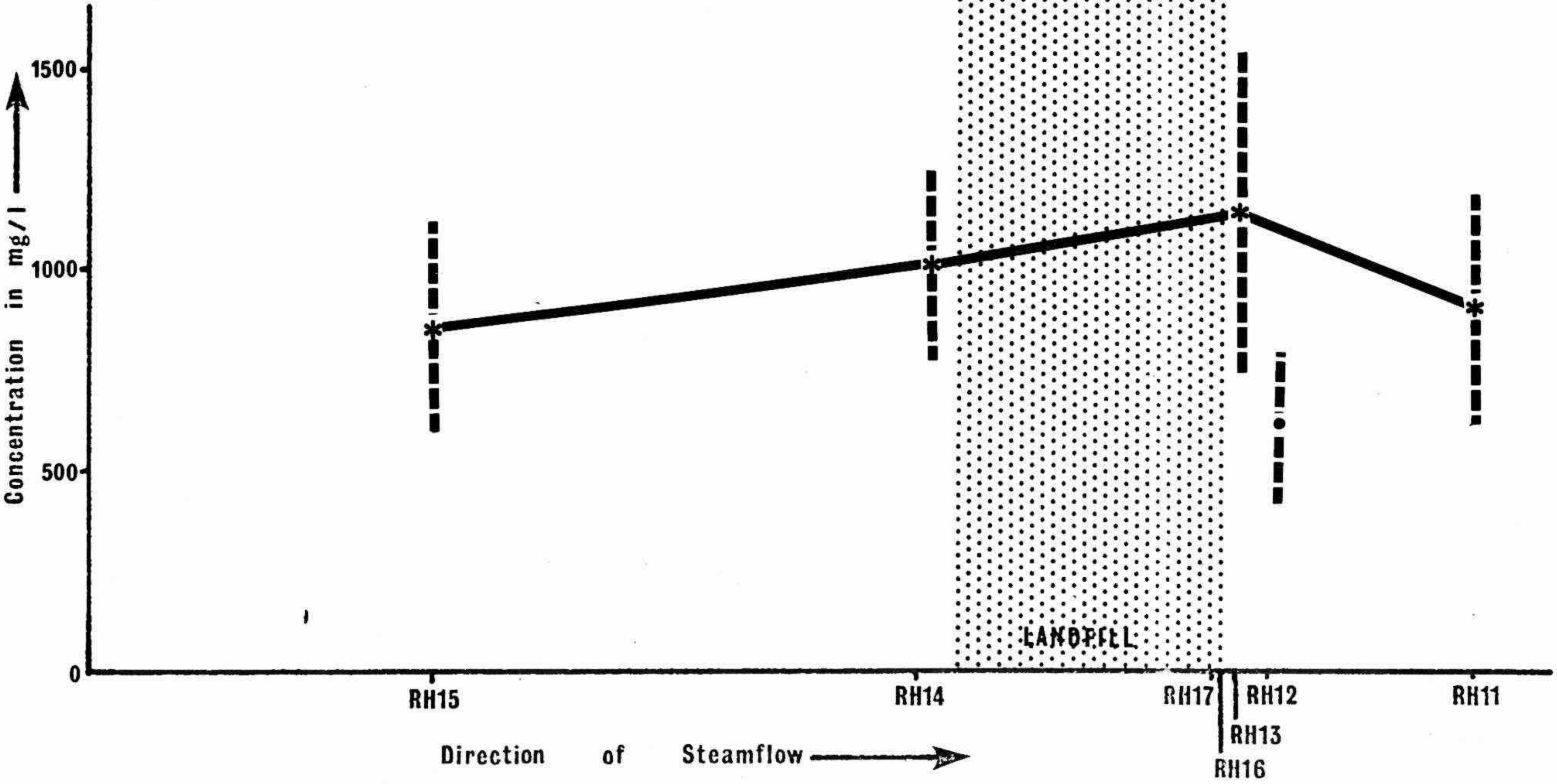


FIGURE 14:
TOTAL SOLIDS



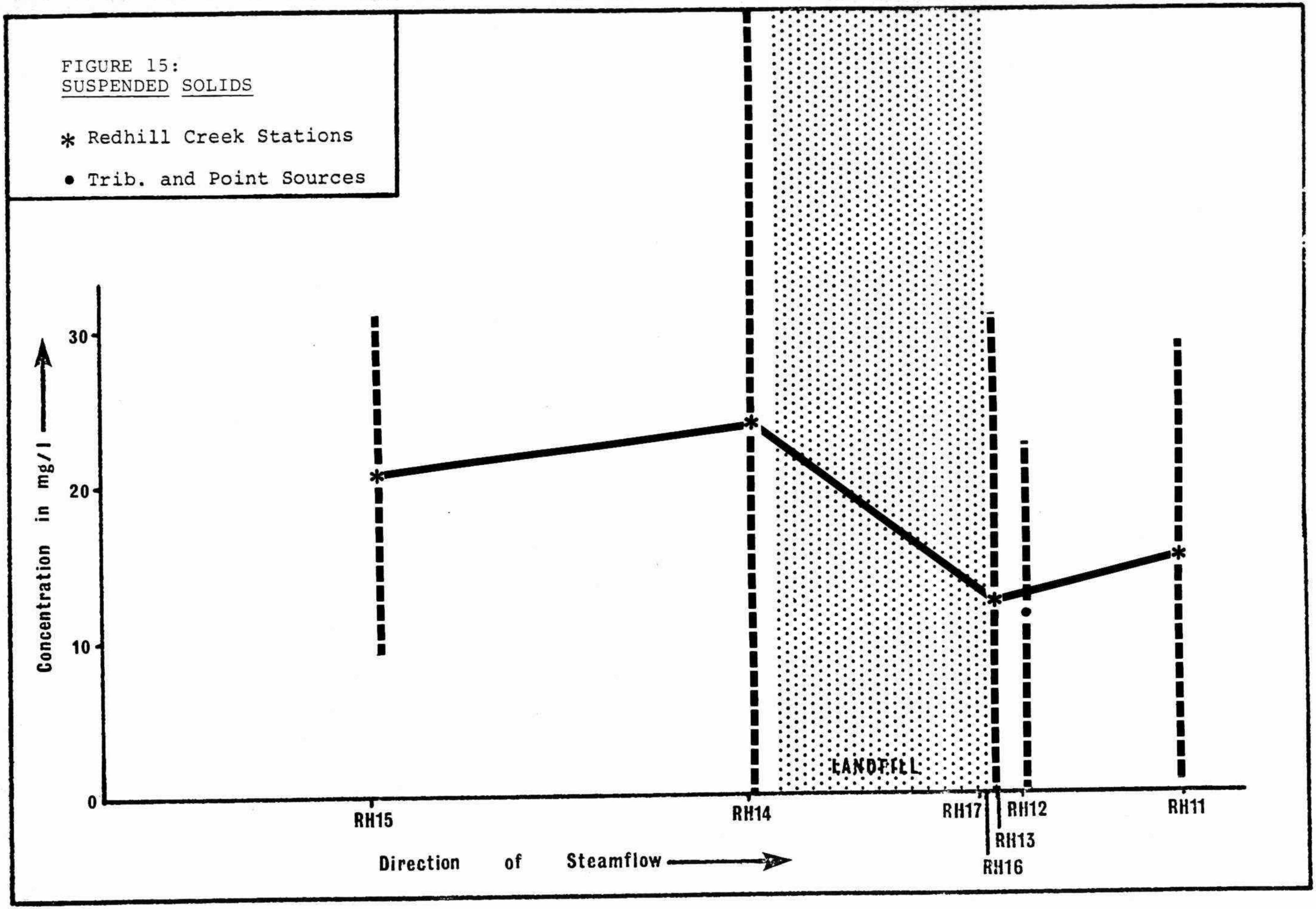


FIGURE 15:
SUSPENDED SOLIDS

FIGURE 16:
TURBIDITY

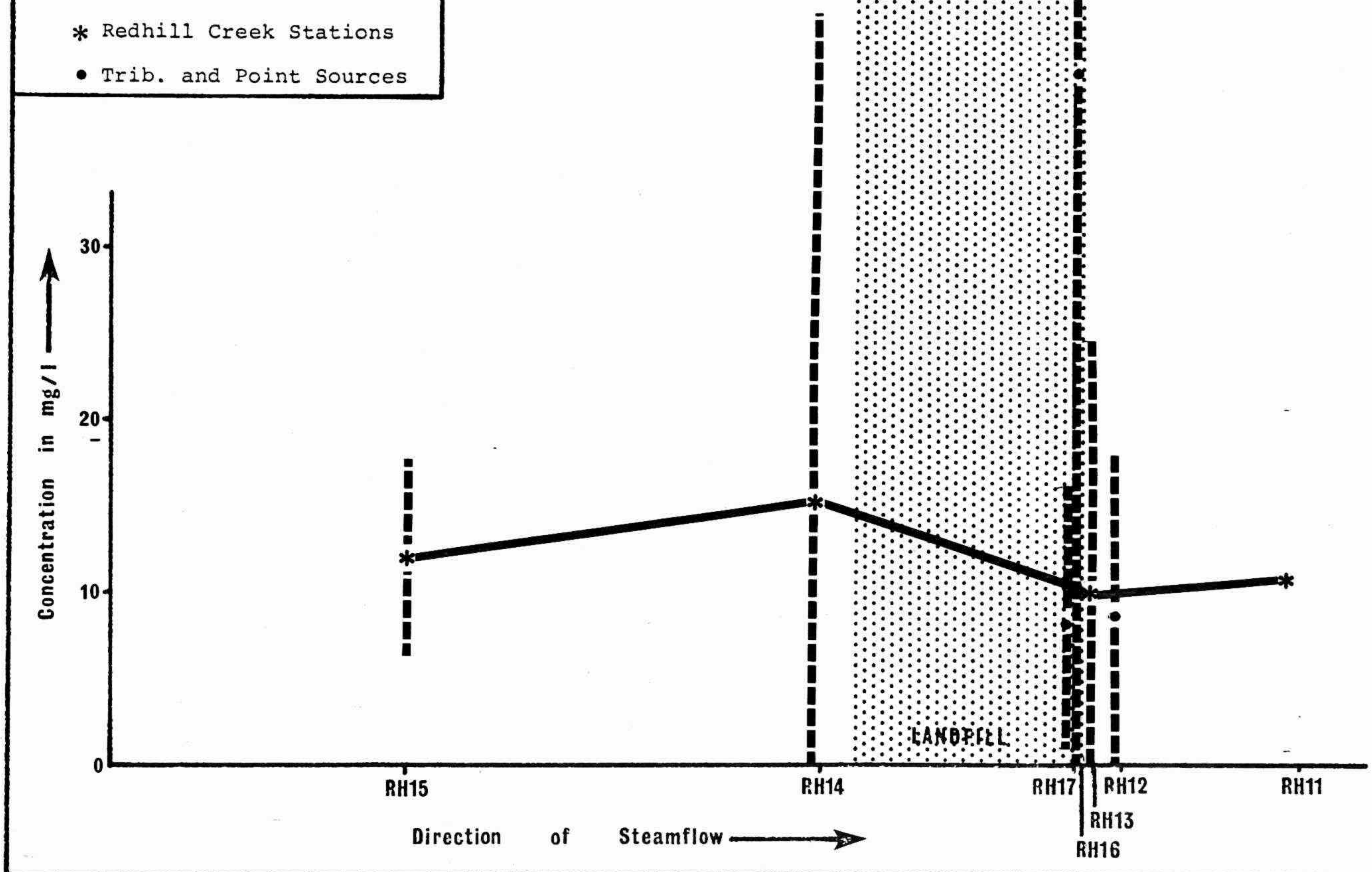
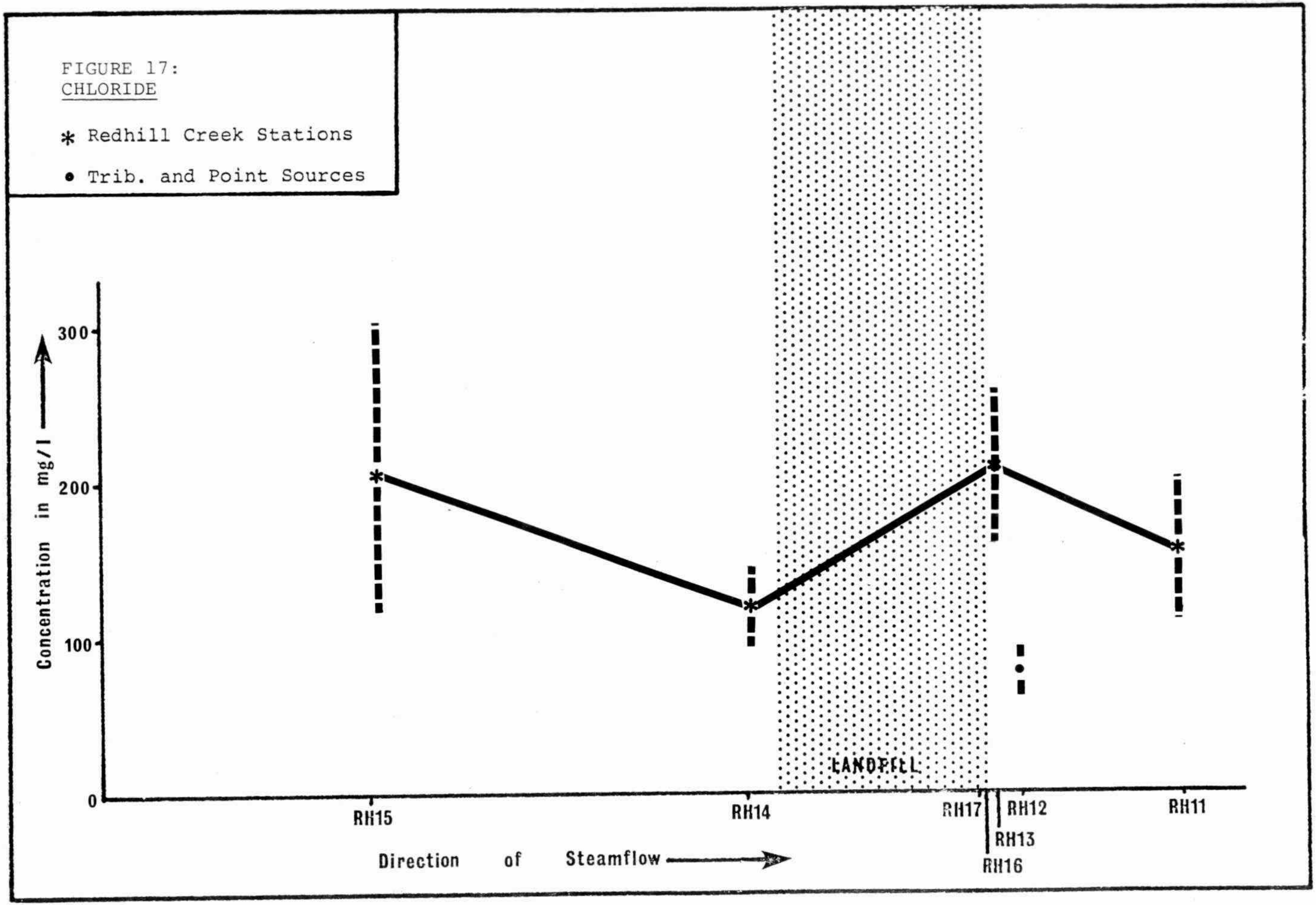


FIGURE 17:
CHLORIDE



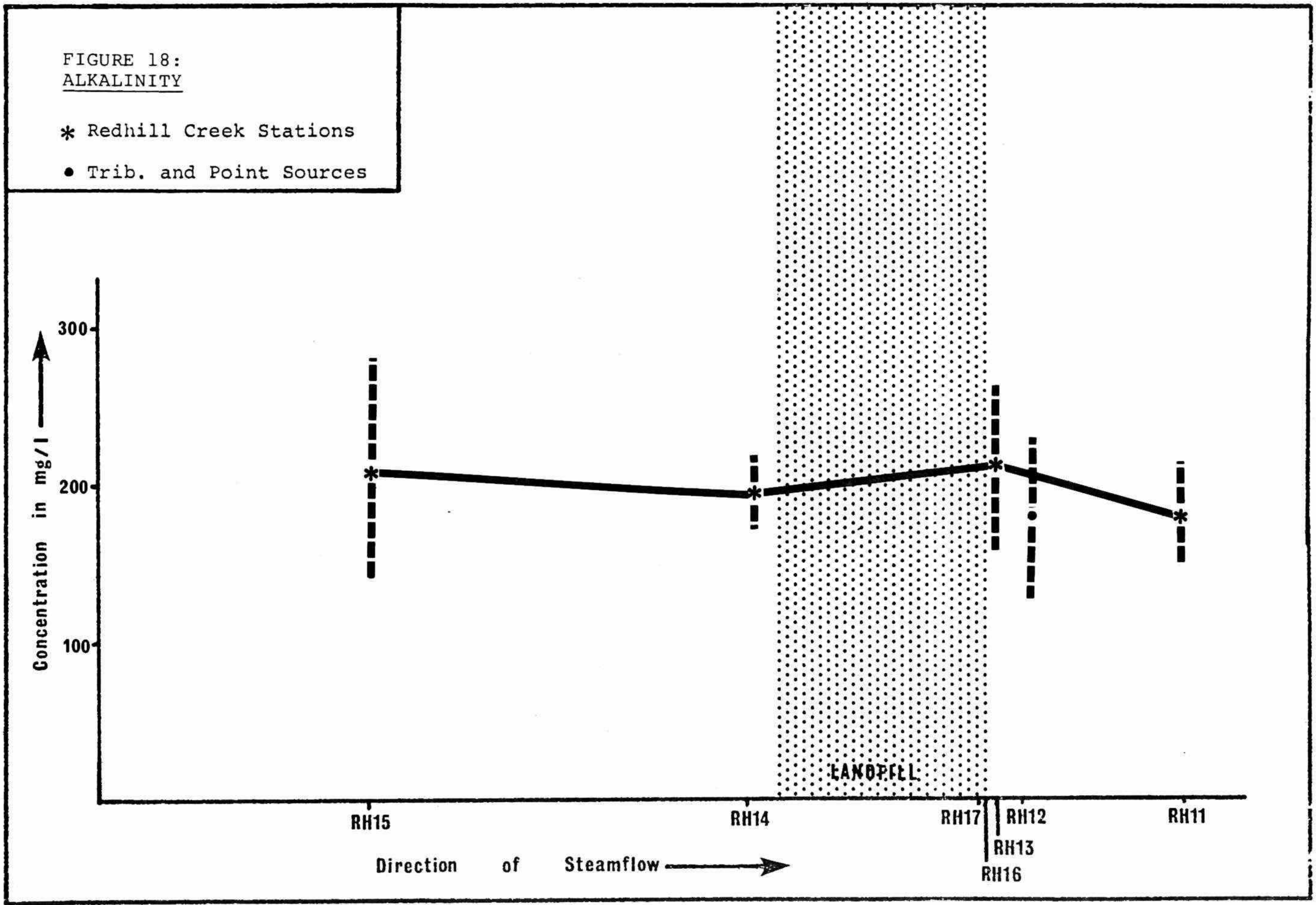


FIGURE 18:
ALKALINITY

FIGURE 19:
5 DAY BOD

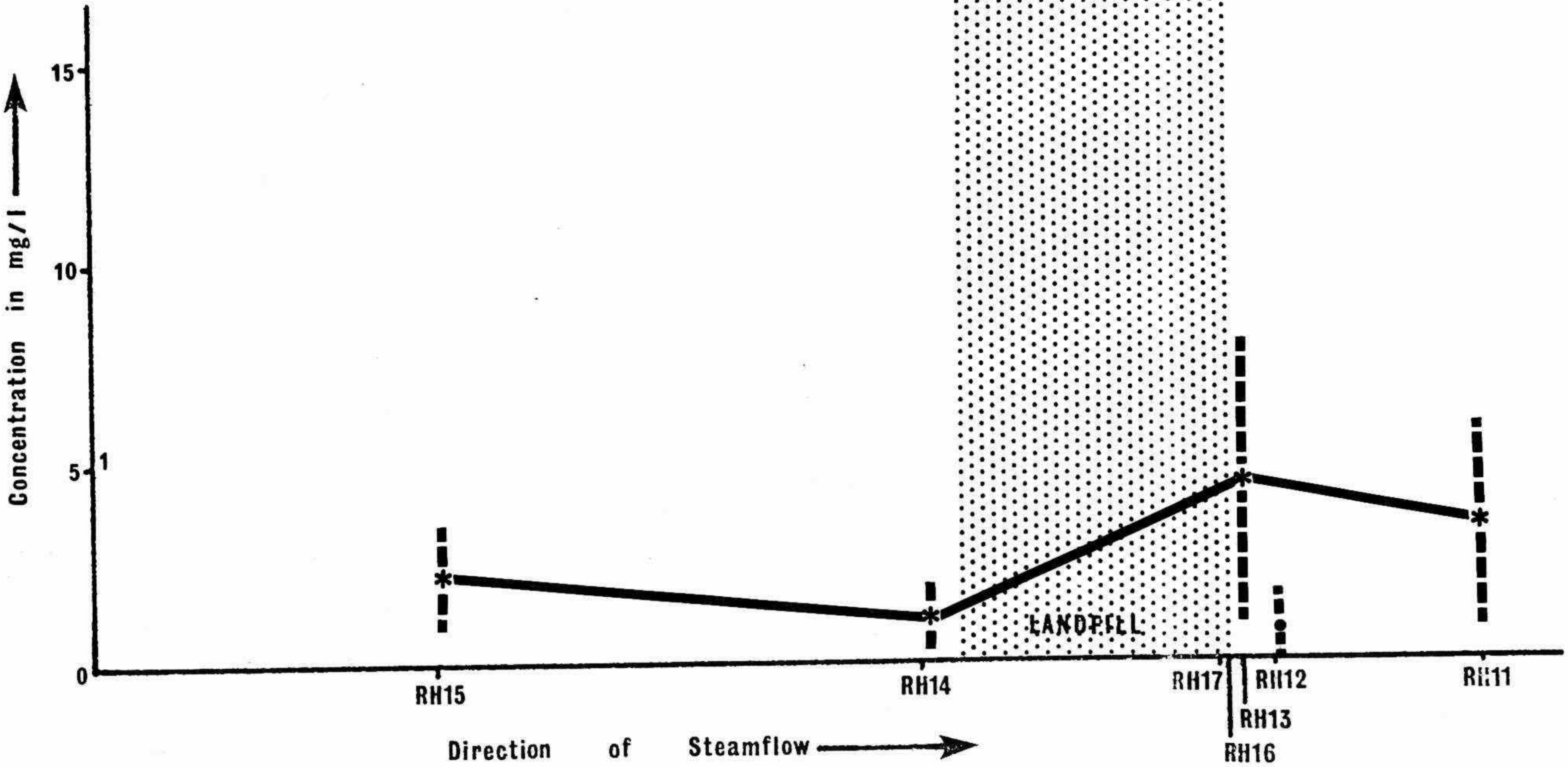


FIGURE 20:
CHEMICAL OXYGEN DEMAND

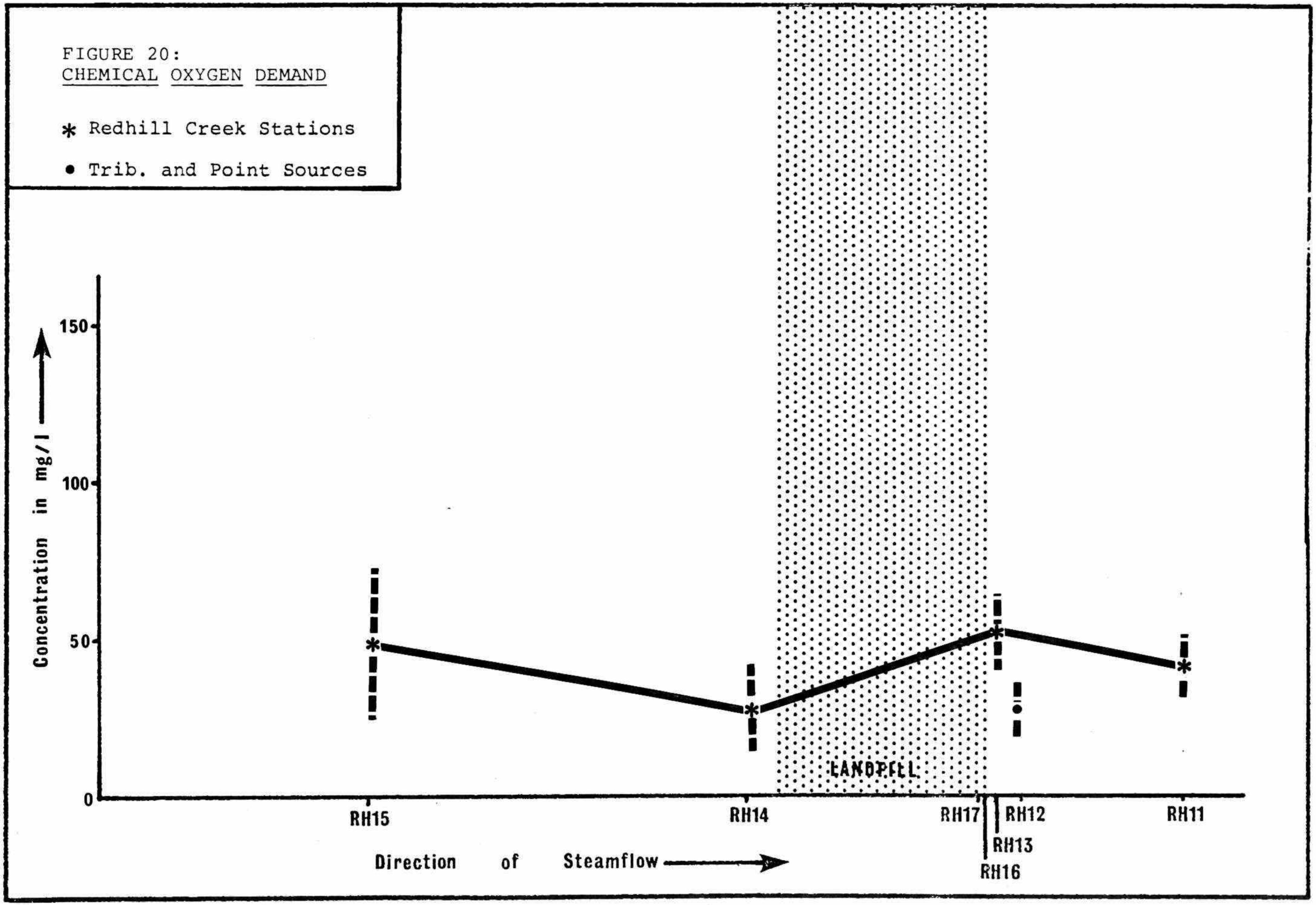
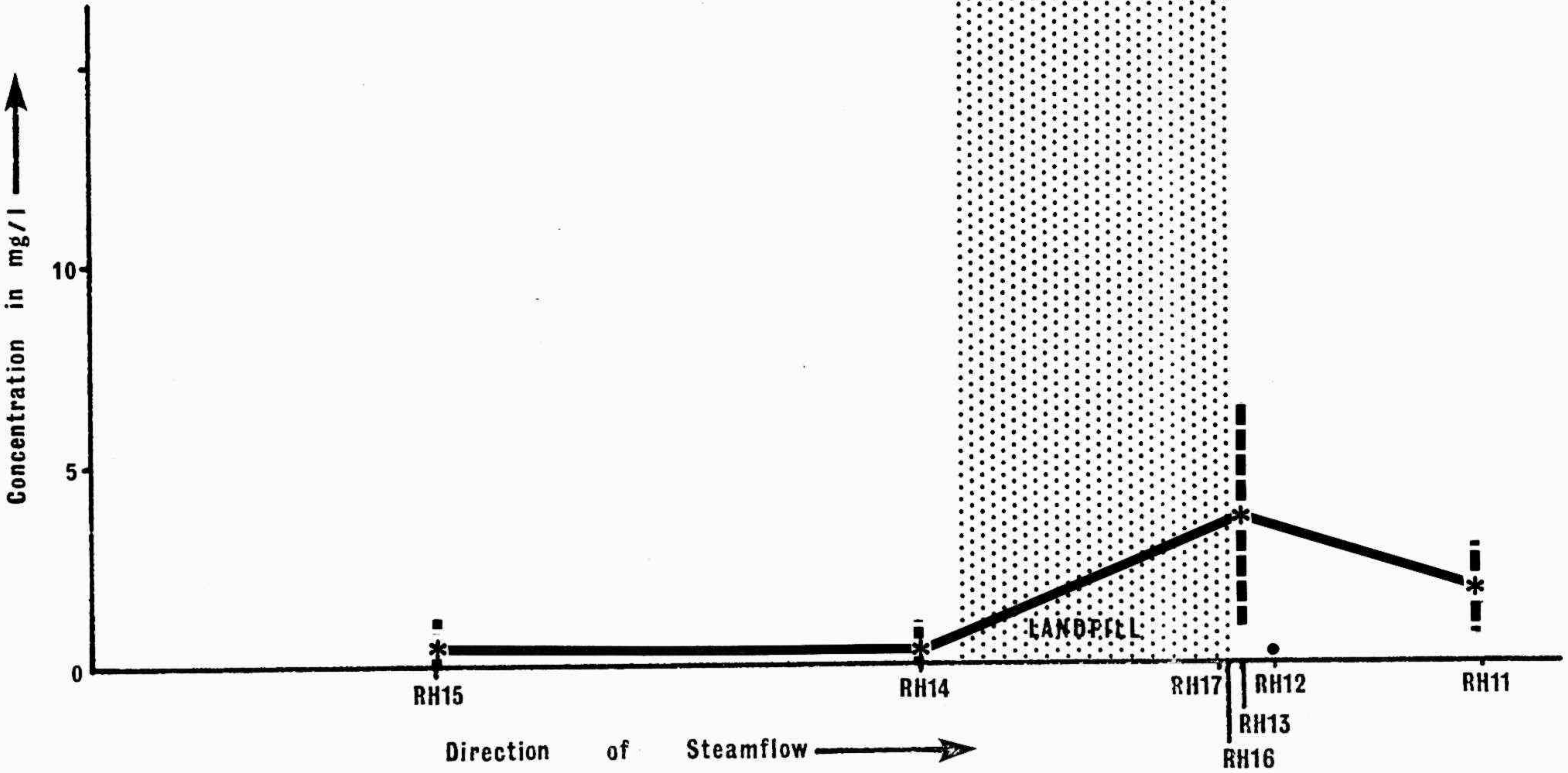


FIGURE 21:
FREE AMMONIA (NH_3)



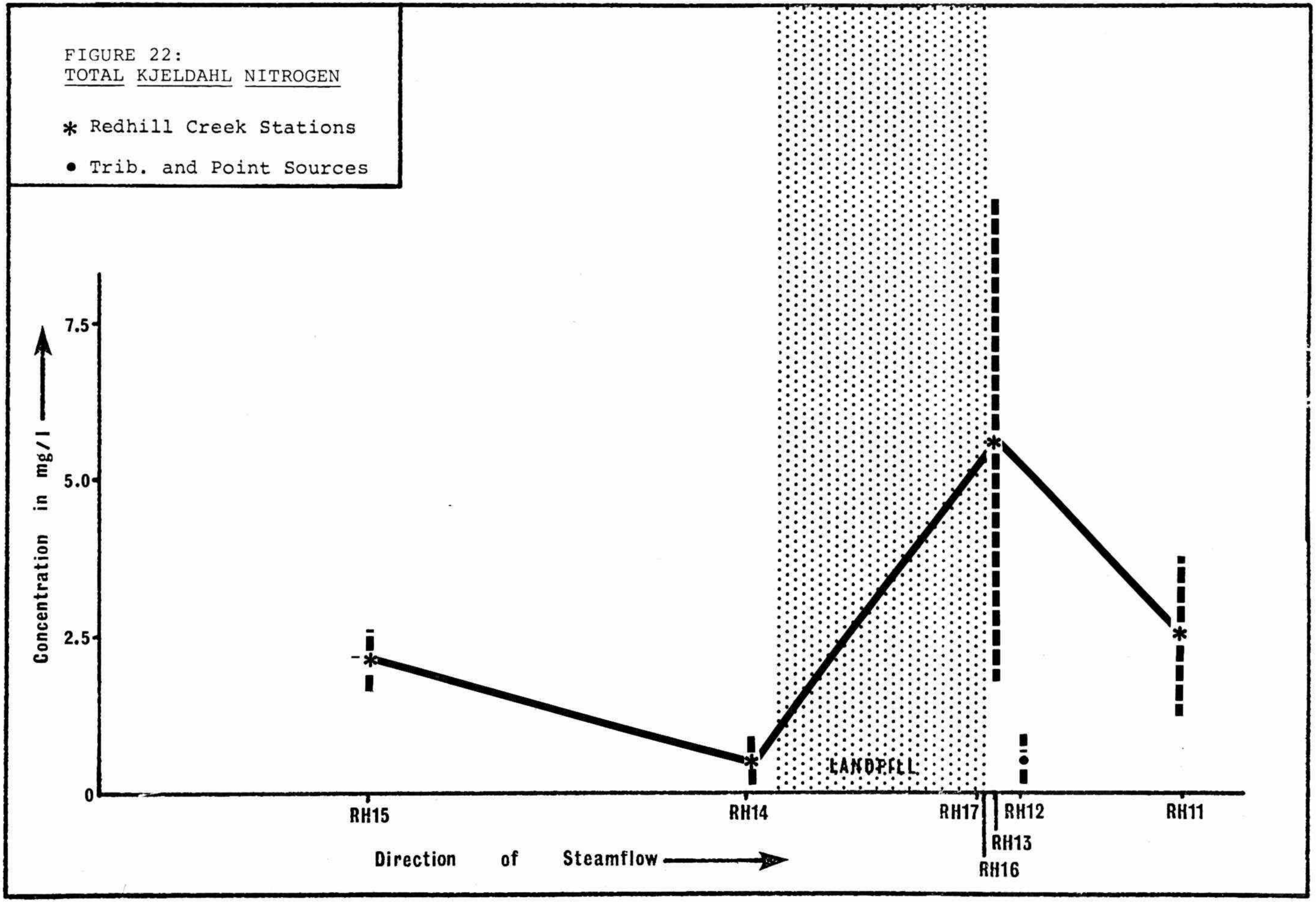
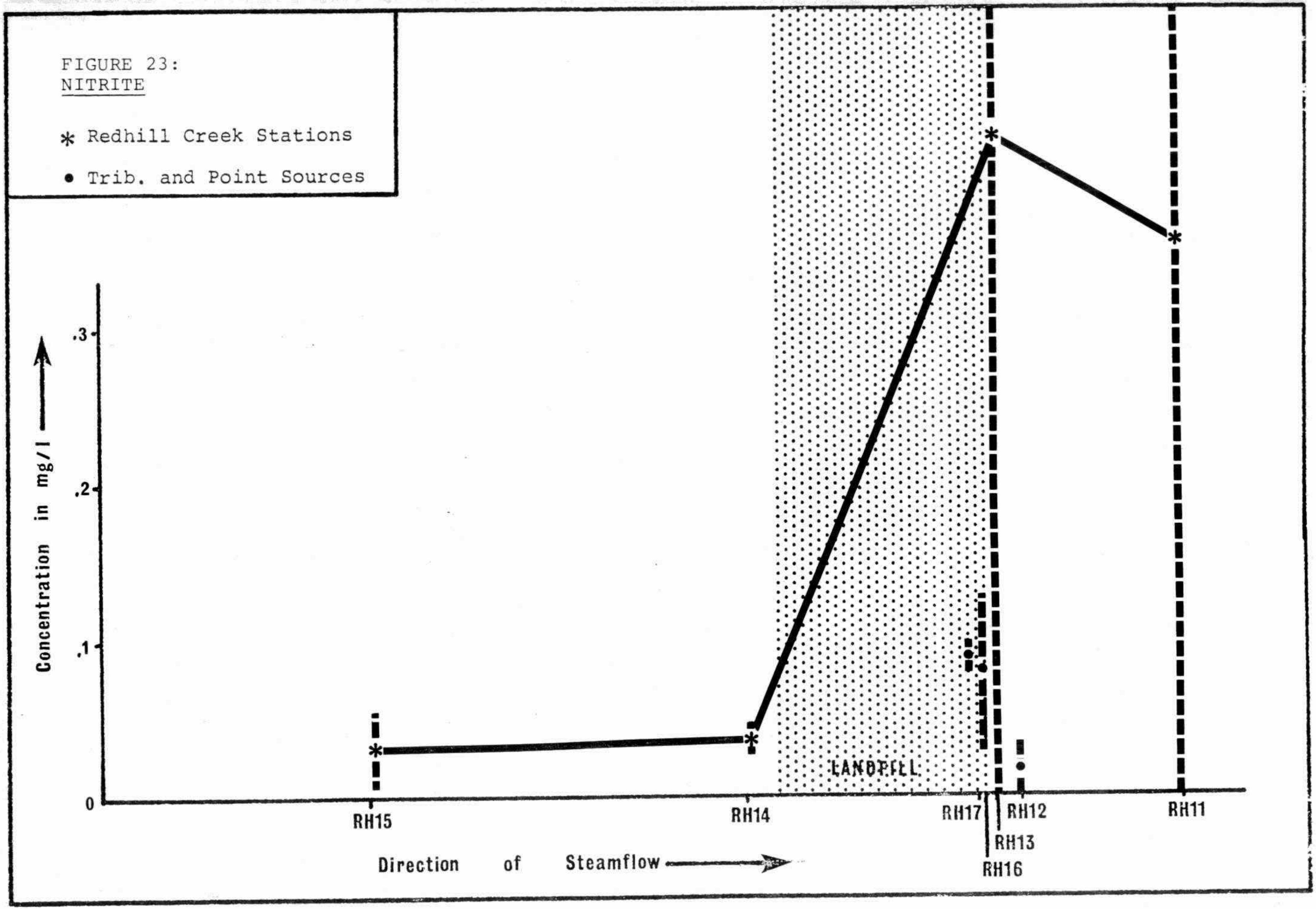


FIGURE 22:
TOTAL KJELDAHL NITROGEN

FIGURE 23:
NITRITE



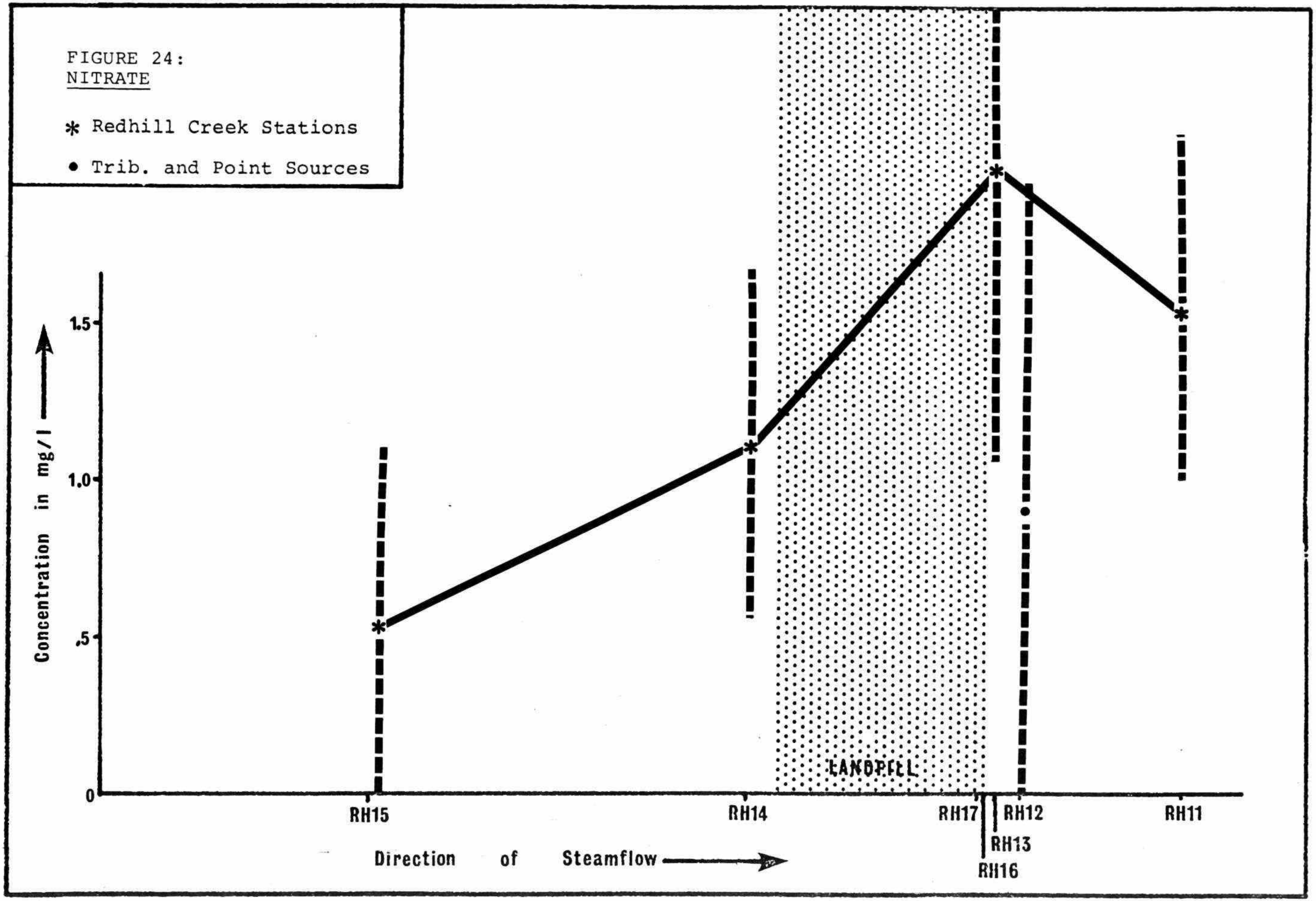


FIGURE 24:
NITRATE

FIGURE 25:
TOTAL PHOSPHORUS

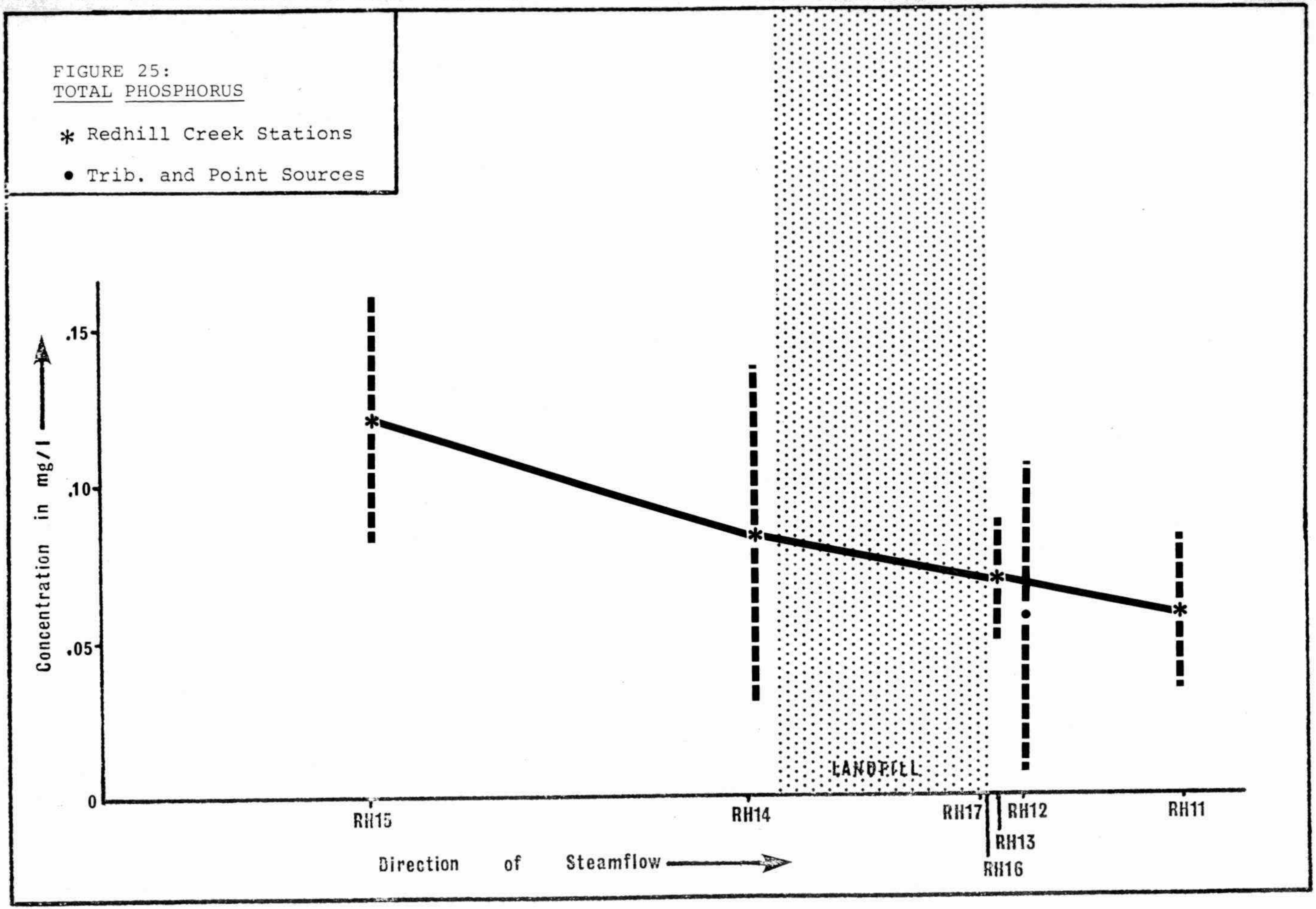
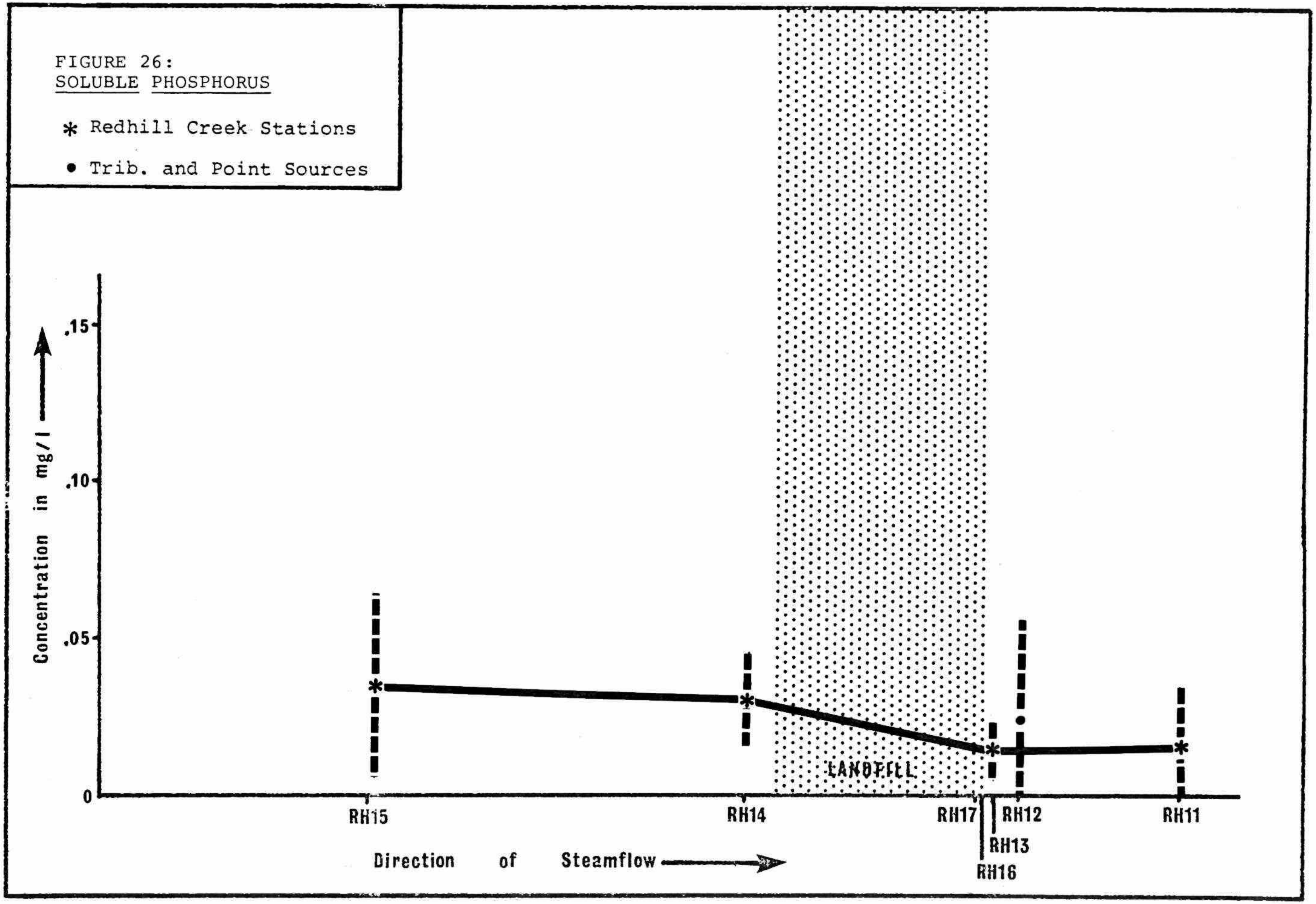


FIGURE 26:
SOLUBLE PHOSPHORUS



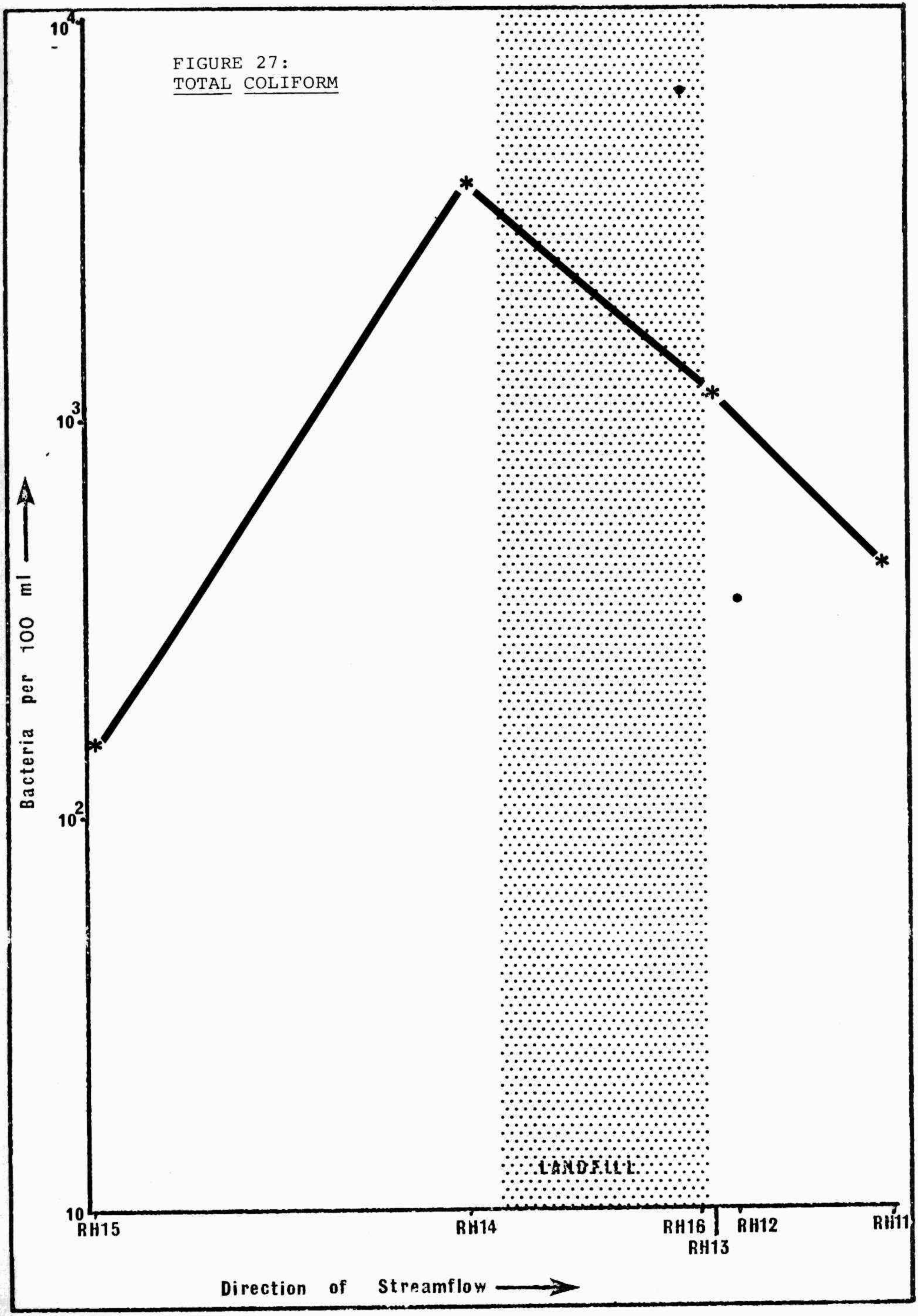


FIGURE 27:
TOTAL COLIFORM

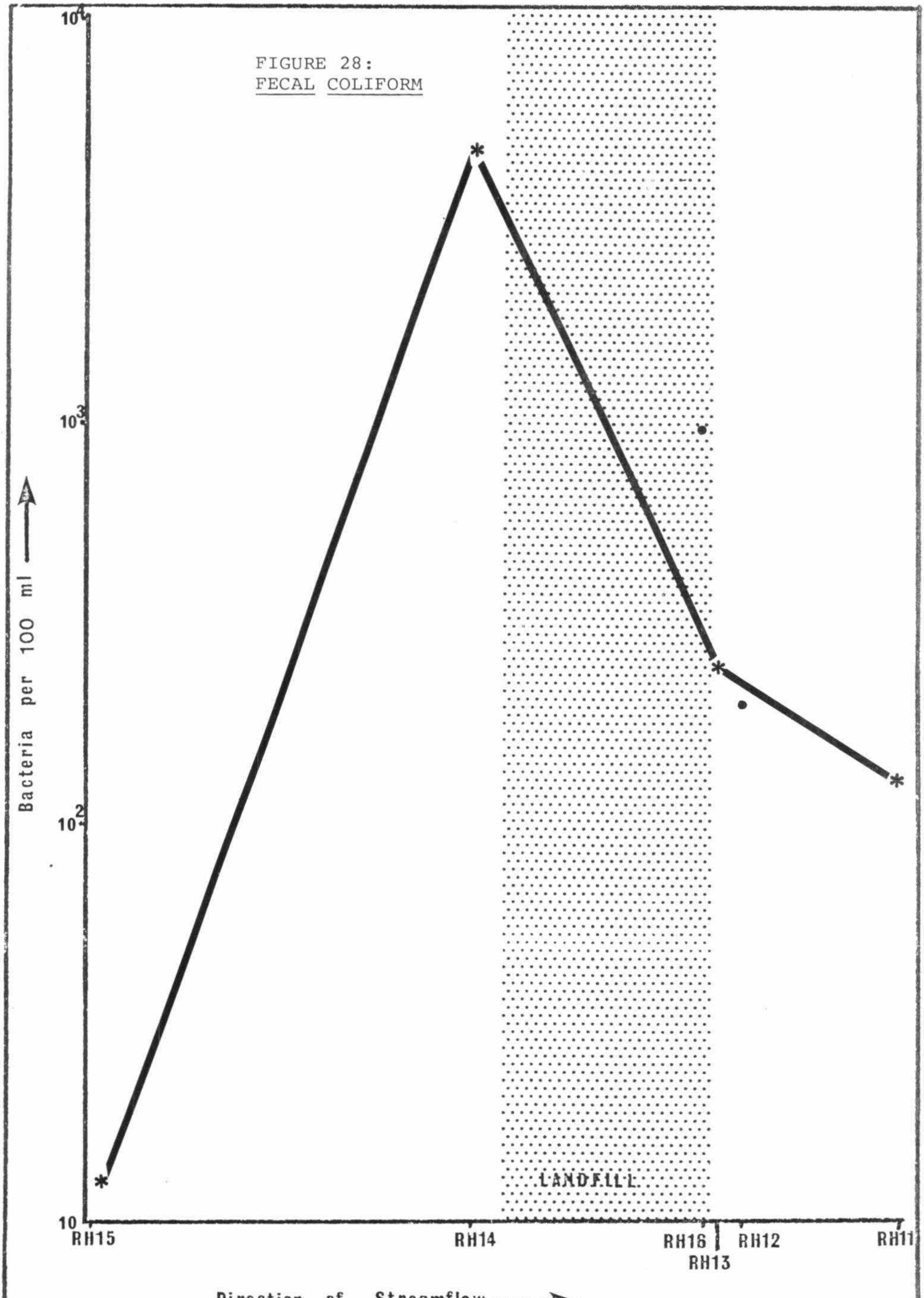


FIGURE 28:
FECAL COLIFORM
10^4
10^3
10^2
10
Bacteria per 100 ml
LANDFILL
RH15
RH14
RH16
RH13
RH12
RH11
Direction of Streamflow

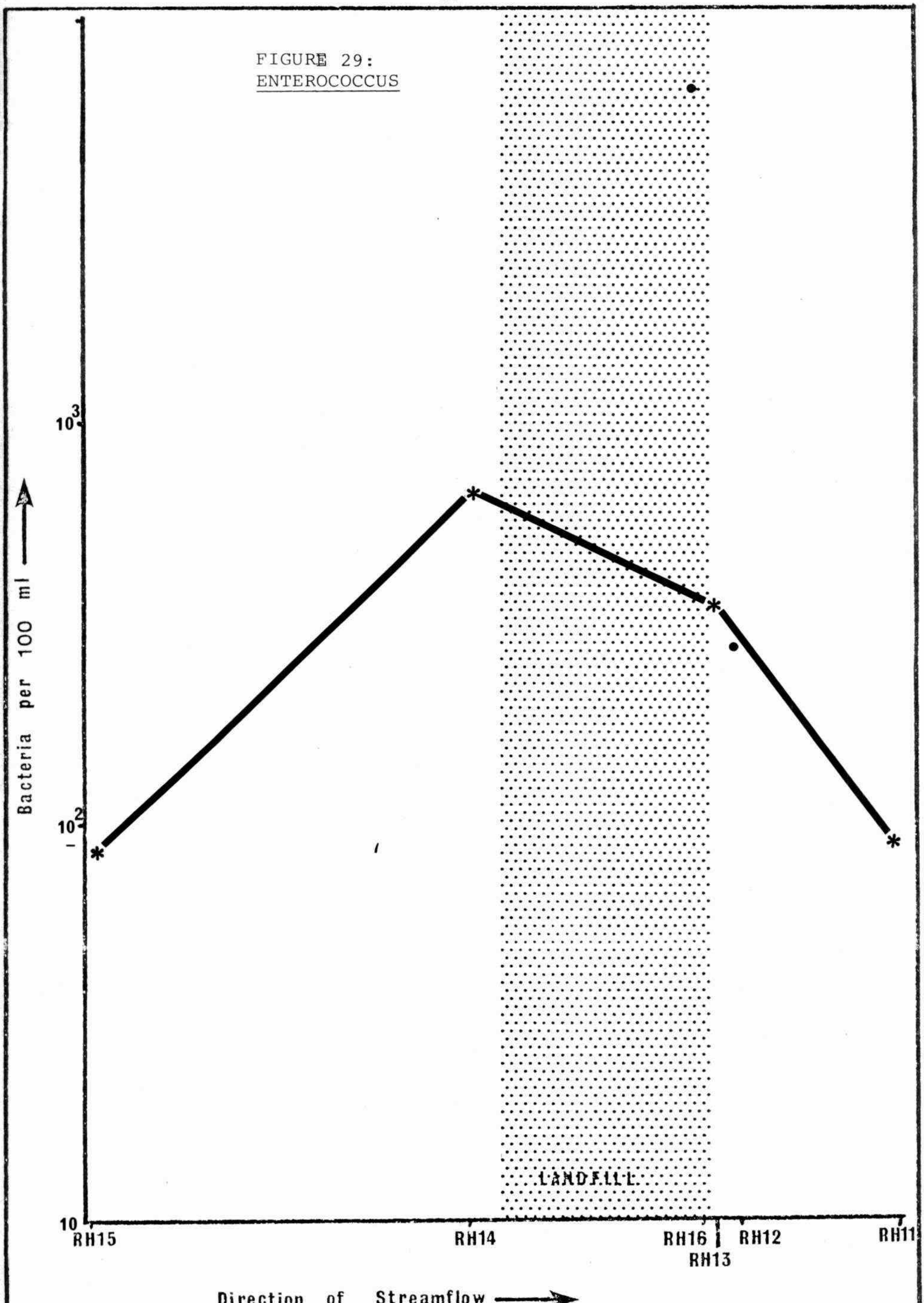


FIGURE 29:
ENTEROCOCCUS
10^3
10^2
10
Bacteria per 100 ml
LANDFILL
RH15
RH14
RH16
RH13
RH12
RH11
Direction of Streamflow

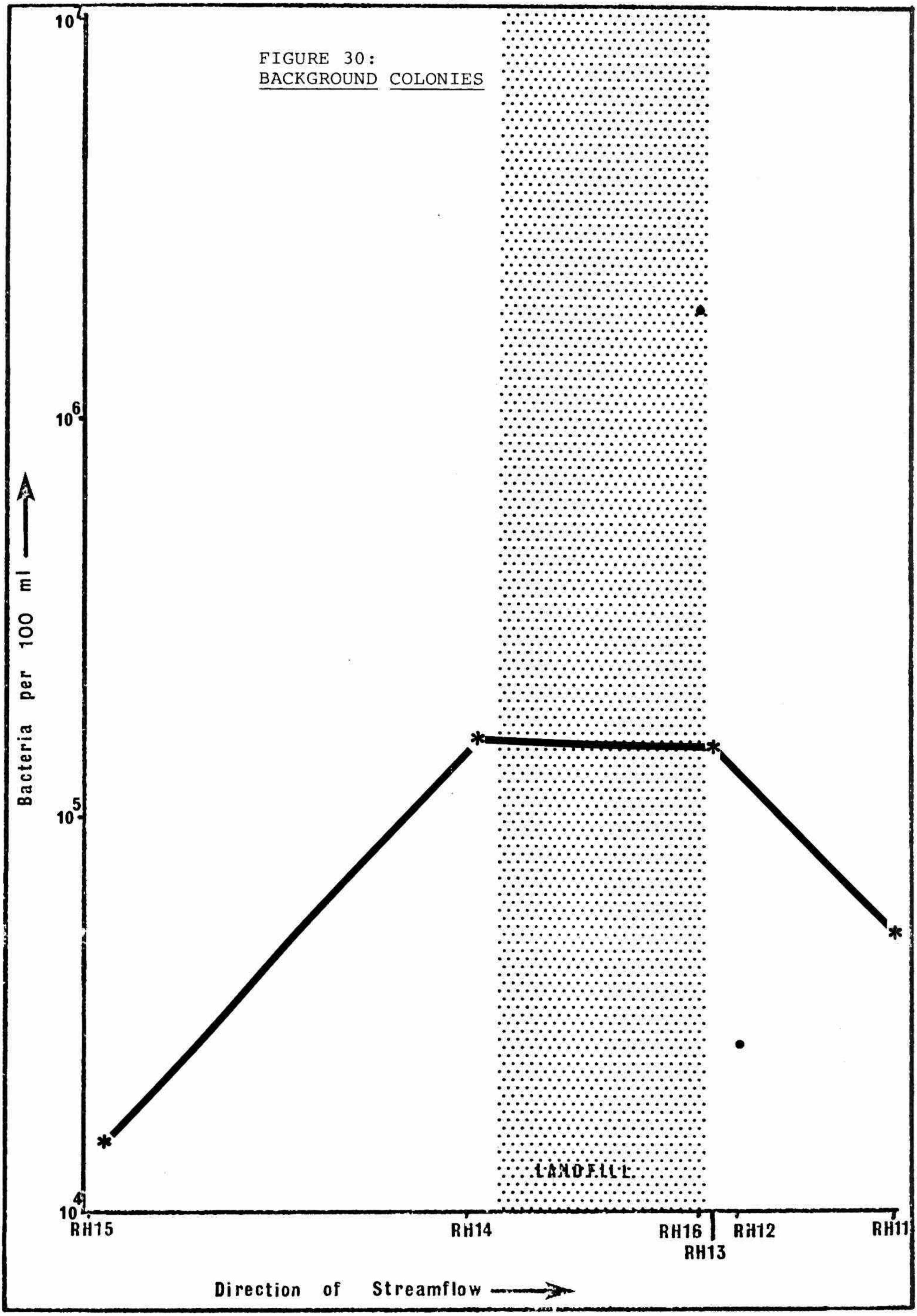


FIGURE 30:
BACKGROUND COLONIES

APPENDIX II

Summary of Analytical Data

Table 3-1(a) Water Quality in Redhill Creek (in mg/l)

Parameter		RH11	RH12	RH13	RH14	RH15
Suspended Solids	$\bar{x}$	14.8	11.5	12.2	24.0	20.6
	s	14.1	11.7	19.0	43.0	11.4
Total Solids	$\bar{x}$	909.	615.	1166	1016	854
	s	277.	196.	403	239	285
Conductivity	$\bar{x}$	1255	848.	1419	1270	1270
	s	348	227	767	230	372
Turbidity	$\bar{x}$	11.1	9.12	10.3	15.7	12
	s	9.9	9.77	14.9	28.6	5.7
Alkalinity	$\bar{x}$	183	183	214	197	213
	s	33	49	46.3	22	65.9
pH	$\bar{x}$	7.83	8.04	8.23	7.96	7.87
	s	.25	.33	.49	.20	.31
Chloride	$\bar{x}$	157	79.2	212	122	214
	s	40.5	15.2	49.7	27	89.2
BOD_5	$\bar{x}$	3.5	.983	4.52	1.28	2.26
	s	2.5	.728	3.53	.83	1.13
COD	$\bar{x}$	41.5	28.8	51.2	28.3	47
	s	9.9	9.97	13.8	14.2	23
Free Ammonia	$\bar{x}$	1.86	.081	3.47	.140	.279
	s	1.21	.120	2.81	.064	.367
Total Kjeldhal Nitrogen	$\bar{x}$	2.64	.555	5.78	.638	1.144
	s	1.27	.309	4.07	.230	.577
Nitrite	$\bar{x}$	.36	.019	.45	.039	.030
	s	.43	.012	.56	.014	.028
Nitrate	$\bar{x}$	1.57	.911	2.02	1.126	.535
	s	.54	1.096	.94	.560	.640
Total Phosphorus	$\bar{x}$	.059	.058	.070	.084	.123
	s	.026	.051	.021	.054	.040
Soluble Phosphorus	$\bar{x}$	.014	.022	.013	.029	.033
	s	.021	.029	.011	.016	.029

Note: $\bar{x}$ = Arithmetic Mean
s = Standard Deviation

Table 3-1(b) Aqueous Heavy Metals in Redhill Creek (mg/l)

Parameter		RH11	RH12	RH13	RH14	RH15
Total Iron	$\bar{x}$	.80	.64	.685	.94	.954
	s	.71	.74	.895	1.65	.42
Arsenic	$\bar{x}$	.001	.001	.001	.001	.002
	s	0	0	0	0	.001
Cadmium	$\bar{x}$	.006	.006	.006	.006	.006
	s	.002	.002	.002	.002	.002
Copper	$\bar{x}$	.012	.012	.02	.01	.014
	s	.004	.004	.01	.01	.005
Lead	$\bar{x}$	<.03	<.03	<.03	<.03	<.03
	s	0	0	0	0	0
Manganese	$\bar{x}$	.148	.095	.09	.11	.46
	s	.056	.069	.05	.06	.32
Nickel	$\bar{x}$	.025	.025	.025	.03	.03
	s	.010	.010	.010	.01	.01
Zinc	$\bar{x}$	.058	.017	.08	.15	.02
	s	.044	.005	.07	.14	.01

Note: $\bar{x}$ = Arithmetic Mean
s = Standard Deviation

Table 3-1(c) Bacterial Data in Redhill Creek (# per 100 ml)

Parameter	RH6*	RH11	RH12	RH13	RH14	RH15
Total	720,000	4,600	3,500	12,000	41,000	1,500
Background Colonies	2,630,000	51,000	26,000	150,000	160,000	15,000
Fecal Coliform	20,800	130	200	250	1,500	13
Fecal Streptococci	1,900	90	280	350	680	88
FC/FS Ratio	11.	1.4	.71	.71	2.21	.15

(mean calculated as Geometric means)

Note RH6 is at Barton Street

Table 3-2(a) Chemical Analysis of Leachate and Surface Runoff

		RH16	RH17	RH18	WRH19
Suspended Solids	$\bar{x}$	166	430	199	35
	s	110	650	180	26
Total Solids	$\bar{x}$	10,950	8,600	8,000	4,820
	s	3,100	1,200	2,700	1,600
Turbidity	$\bar{x}$	42.9	8.2	23	19
	s	62.8	6.8	14	12
Chloride	$\bar{x}$	2920	1811	2,800	1,720
	s	873	328	2,130	85
Alkalinity	$\bar{x}$	4,170	4,840	3,670	2,750
	s	829	763	1,020	180
pH	$\bar{x}$	7.99	7.88	8.38	10.3
	s	.13	.14	.16	1.4
Conductivity	$\bar{x}$	16,200	12,100	11,450	8,970
	s	4,260	1,700	3,600	160
BOD$_5$	$\bar{x}$	121	280	110	295
	s	24	210	53	21
COD	$\bar{x}$	1630	2660	1200	1870
	s	796	1390	380	290
Free Ammonia	$\bar{x}$	263	450	120	280
	s	55	100	32	52
Total Kjeldahl Nitrogen	$\bar{x}$	323	657	147	320
	s	61	160	27	60
Nitrite	$\bar{x}$	.08	.09	.12	.05
	s	.05	.01	.10	0
Nitrate	$\bar{x}$	.12	.15	.12	.1
	s	.04	.07	.04	0
Total Phosphorus	$\bar{x}$	2.68	10.1	2.06	1.87
	s	.79	2.3	.7	1.24
Soluble Phosphorus	$\bar{x}$	1.04	4.6	.46	.04
	s	.58	1.9	.30	.02

Note: $\bar{x}$ = Arithmetic Mean
s = Standard Deviation

Table 3-2(b) Bacterial Analyses of Leachate and Surface Runoff

	RH16	RH17	RH18
Total Coliform	70,000	35,500	290,000
Background Colonies	1,900,000	925,000	8,800,000
Fecal Coliform	970	10	19,000
Fecal Streptocci	7,100	23,700	32,000
FC/FS Ratio	.14	.00	.59

Means are calculated as Geometric Means

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